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# Economic Impact Analysis of Proposed Effluent Limitations Guidelines, New Source Performance Standards and Pretreatment Standards for the

# Pulp, Paper and Paperboard Mills

## Point Source Category
## Volume I

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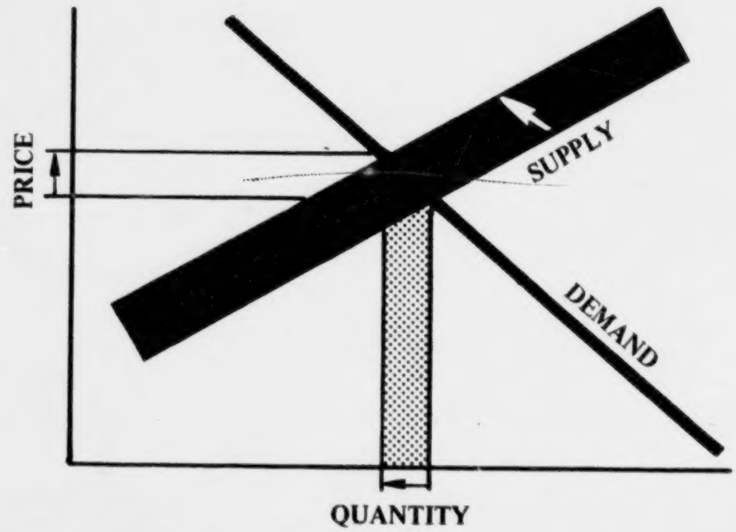

# ECONOMIC IMPACT ANALYSIS OF PROPOSED EFFLUENT LIMITATIONS GUIDELINES, NEW SOURCE PERFORMANCE STANDARDS AND PRETREATMENT STANDARDS FOR THE PULP, PAPER AND PAPERBOARD MILLS POINT SOURCE CATEGORY

## Volume I

## Economic Impact Analysis

Prepared for

U. S. Environmental Protection Agency
Office of Water Regulations and Standards
Washington, D.C. 20460

by

Meta Systems Inc.
Cambridge, Massachusetts

Data Resources, Inc.
Lexington, Massachusetts

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# PREFACE

This document is a contractor's study prepared for the Office of Water Regulations and Standards of the Environmental Protection Agency (EPA). The purpose of the study is to analyze the economic impact which could result from the application of effluent standards and limitations issued under Sections 301, 304, 306 and 307 of the Clean Water Act to the pulp, paper and paperboard industry, including builders' paper and roofing felt manufacturing.

The study supplements the technical study (EPA Development Document) supporting the issuance of these regulations. The Development Document surveys existing and potential waste treatment control methods and technology within particular industrial source categories and supports certain standards and limitations based upon an analysis of the feasibility of these standards in accordance with the requirements of the Clean Water Act. Presented in the Dvelopment Document are the investment and operating costs associated with various control and treatment technologies. The attached document supplements this analysis by estimating the broader economic effects which might result from the application of various control methods and technologies. This study investigates the effect in terms of product price increases, effects upon production and the continued viability of affected plants, effects upon foreign trade and other competitive effects.

The study has been prepared with the supervision and review of the Office of Water Regulation and Standards of EPA. This report was submitted in fulfillment of Contract No. 68-01-4675 by Meta Systems, Inc and completed in December, 1980.

This report is being released and circulated at approximately the same time as publication in the Federal Register of a notice of proposed rule making. The study is not an official EPA publication. It will be considered along with the information contained in the Development Document and any comments received by EPA on either document before or during final rule making proceedings necessary to establish final regulations. Prior to final promulgation of regulations, the accompanying study shall have standing in any EPA proceedings or court proceeding only to the extent that it represents the views of the contractor who studied the subject industry. It cannot be cited, referenced, or represented in any respect in any such proceeding as a statement of EPA's views regarding the pulp, paper and paperboard industry.

## ACKNOWLEDGEMENTS

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Penelope H. Schafer
Project Director

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# Section 1

## Executive Summary

### Introduction

This report analyzes the economic impacts of water pollution controls on the Pulp, Paper and Paperboard Industry. This study was prepared under the supervision of the Office of Analysis and Evaluation, U.S. Environmental Protection Agency. As required by the Clean Water Act, this study presents for consideration the economic impacts of regulations proposed under that Act which would control the industry's discharge of its effluents.

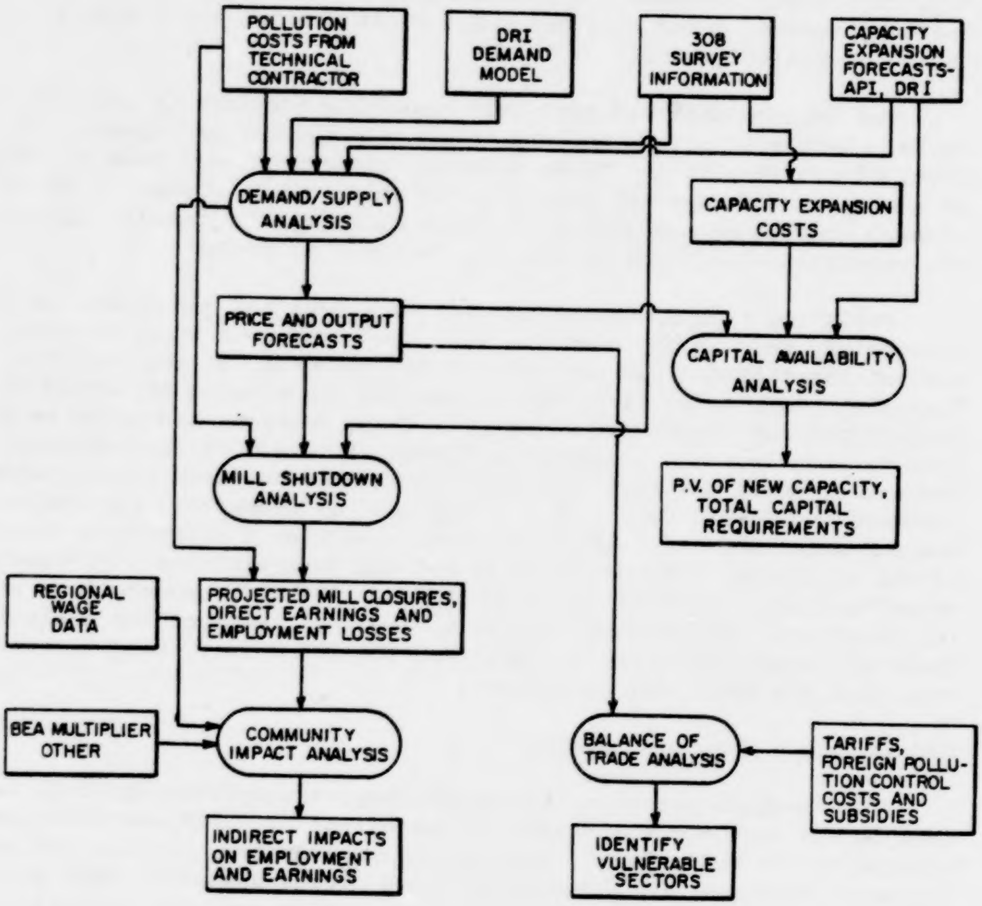
The impacts analyzed are: the resulting increase in production costs, changes in prices and the quantity produced, and changes in the level of profitability. These economic impacts in turn lead to impacts on the amount of capacity expansion or contraction, number of mills closed, impacts on the number of persons employed, community impacts and the regulations' effects on the U.S. balance of trade.

Following this Executive Summary is a detailed discussion of the methodology used in the economic analysis. The next three sections present descriptions and analyses of the structure of the industry, financial profiles of firms and mills, and the pricing structure of the Pulp, Paper and Paperboard Industry. These sections are based on data from various sources, including a financial survey of the industry, Data Resources, Inc., the technical contractor, the American Paper Institute, Standard and Poor's Corp., U.S. Department of Commerce, the Federal Trade Commission, and trade literature. Section 6 presents a description of the regulatory options analyzed and the potential costs of other (non-water quality) environmental regulations. The last two sections present the results of the economic analysis, and the limits of the analysis. These are based primarily on data from the 308 Survey, Data Resources, Inc., and the technical contractor.

### Methodology - Economic Impacts

This section presents the methodology, assumptions and data sources used in the economic assessment of the effect of BCPCT and BATEA regulations on the Pulp, Paper, and Paperboard Industry. Figure 1-1 shows the major elements and information flows of the analysis. The main elements include the demand/supply analysis, which produces forecasts of price, output, and contribution to capital (revenues less variable costs) used in the rest of the analysis; the capital availability analysis; the

FIGURE 1-1. Overall Information Flows


POLLUTION COSTS FROM TECHNICAL CONTRACTOR
DRI DEMAND MODEL
308 SURVEY INFORMATION
CAPACITY EXPANSION FORECASTS-API, DRI
DEMAND/SUPPLY ANALYSIS
CAPACITY EXPANSION COSTS
PRICE AND OUTPUT FORECASTS
CAPITAL AVAILABILITY ANALYSIS
MILL SHUTDOWN ANALYSIS
P.V. OF NEW CAPACITY, TOTAL CAPITAL REQUIREMENTS
REGIONAL WAGE DATA
PROJECTED MILL CLOSURES, DIRECT EARNINGS AND EMPLOYMENT LOSSES
BEA MULTIPLIER OTHER
COMMUNITY IMPACT ANALYSIS
BALANCE OF TRADE ANALYSIS
TARIFFS, FOREIGN POLLUTION CONTROL COSTS AND SUBSIDIES
INDIRECT IMPACTS ON EMPLOYMENT AND EARNINGS
IDENTIFY VULNERABLE SECTORS

NOTE: RECTANGULAR BOXES DENOTE INFORMATION FLOWS.
OVAL BOXES DENOTE UNITS OF ANALYSIS.

mill shutdown analysis; the employment and community impact analyses which flow directly from the shutdown analysis; and the balance of trade analysis.

The diagram shows the four major sources of information used. The 308 Survey* provided financial and production data on 648 mills (in 636 responses) out of approximately 700 pulp and paper mills in the United States. The technical contractor to the Effluent Guidelines Division, E.C. Jordan Co., Inc., supplied information on the costs and characteristics of the pollution control equipment to be installed. Data from the 308 Survey and E.C. Jordan are central to the generation of the supply functions. Data Resources, Inc. (DRI) provided the econometric demand equations for the model, including the macroeconomic forecasts of certain exogenous variables, and forecasts of capacity expansion. Industry sources such as the American Paper Institute (API) and trade journals provided additional estimates of capacity expansion, as well as other information useful in making decisions at every step of the analysis.

This section also discusses the methodology and data used to calculate a capital recovery factor for the industry.

### Costs of Compliance

Before predicting impacts of the Proposed Regulation on price, output, and contribution to capital, it is necessary to estimate the costs of compliance of individual mills and the industry as a whole. The financial information from the 308 Survey is used to model the cost structure of the industry in 1978. Given the production information from the 308 Survey and data on treatment costs from the technical contractor, costs of compliance per ton are developed and the distribution of unit costs by subcategory and product sector analyzed.

To estimate total costs of compliance in the industry in 1983, forecasts of capacity expansion after 1978 are made based on 308 Survey data, industry reports of planned expansion, and projections by DRI. The expansion forecasts can be used directly to calculate costs of compliance by product sector for mills in place after 1978. To compute costs by subcategory, expansion forecasts for each subcategory must be developed based on the product sector forecasts. It was assumed that expansion after 1978 in each sector would contain the same fractions of integrated subcategories as found in the 308 Survey. Only a small increase in nonintegrated capacity is predicted. In addition, the fraction of new mills subject to New Source Performance Standards (NSPS) was also forecast based on industry expansion plans.

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*This survey, also referred to as the 308 Financial Survey, is described in Appendix 2-A.

Costs of compliance are estimated both for capital costs and total annual costs, i.e., operation and maintenance costs, energy costs, and annual capital costs. To estimate annual capital costs, a methodology for estimating industry's cost of capital and the capital recovery factor is developed. The cost of capital is also used as a discount rate in present value calculations in the capital availability and mill closure analyses described below.

## Impacts on Price, Output, and Contribution to Capital

The core of the approach to estimating the impact of BCPCT and BATEA regulations on the industry is a microeconomic demand/supply analysis for each market (product) sector of the industry. The analysis produces both a base case (assuming no new regulations) forecast of price, output, and contribution to capital for each product sector and forecasts of the effects of the cost of various treatment options on those variables. The approach assumes that individual product markets are competitive and that prices depend on the variable costs of the marginal (high cost) mills in the various sectors. In the post-control cases, variable costs are assumed to include total annual costs of pollution control. Market or product sectors rather than subcategories are used because the relevant set of competing products depends on product type, not manufacturing process. The organization of the industry into product sectors corresponds closely to product groups used by API.

For each sector, supply curves are constructed from manufacturing cost and production data collected in the 308 Survey and pollution control cost estimates provided by the technical contractor. The supply curves explicitly relate mill subcategories, the basis for defining treatment costs, with product sectors, where the interaction of demand and supply takes place. Supply curves are generated for a base case with no additional pollution control requirements and for each of several control options. The supply curves for different years are adjusted to account for forecasts of capacity expansion through 1985.

The demand for each product sector is modeled using demand equations estimated by Data Resources, Inc. and linked with DRI's macroeconomic forecasts over the period of the analysis, 1979-85. This provides a demand forecast to match the capacity expansion forecasts on the supply side.

The interaction between supply and demand is modeled by solving the system of supply and demand equations for each product sector for equilibrium values of price, output, and contribution to capital for each year of the forecast period.

### Capital Availability Analysis

The capital availability analysis examines the ability of the industry to finance investments in new capacity both without and with pollution controls. The results of the analysis also provide a check on the capacity expansion forecasts used in the demand/supply analysis. Two different approaches are used in the analysis. The first implicitly assumes that if investments are profitable, given current costs of capital, the capital market will provide the money for those investments. Given costs of capacity expansion and pollution control and price forecasts from the demand/supply analysis, the present value of new capacity in each product sector is examined. The second approach focuses on the ability of the industry to finance capacity expansion from its current cash flow without relying on outside sources of capital. This corresponds to a worst-case "capital-squeeze" situation. Cash flow is analyzed both for each product sector as a whole and for individual mills.

### Closure Analysis

Rather than using a limited set of model mills, the closure analysis uses data from the 308 Survey to model the full range of product/process mixes and financial conditions found in the industry. Each mill is subjected to a shutdown formula which compares the present value of staying open with the opportunity cost of salvaging the plant immediately. Those mills whose salvage value is greater than the discounted stream of net revenues are selected as closure candidates. Cost and production data are taken from the 308 Survey and price forecasts come from the demand/supply analysis. Closures are forecast both for a base case without further water pollution controls and for the added impacts of the Proposed Regulation and the Alternative Options.

The closure analysis also predicts direct losses in employment. Employment data come from the 308 Survey of the technical contractor. As a comparison, total losses in employment resulting from reductions in output are calculated by applying average productivity figures to output losses in each product sector.

### Community Impacts

Mill closures will have indirect effects on employment and earnings. A simple input/output framework is used to derive the "multiplier" effects on earnings (wages and salaries, other labor income, and payments to proprietors) of a change in "final demand" due to a closure. The multipliers are taken from the national input/output model of the Bureau of Economic Analysis. Indirect affects on earnings are used to estimate indirect effects on employment by applying aggregate regional employment/earnings ratios.

It was not possible to estimate effects of closures on state and federal tax revenues. Revenues of municipalities obtained from user charges and industrial cost recovery of industrial dischargers to publicly-owned treatment works (POTW's) will not be affected. This is because dischargers to POTW's will not face treatment costs under the Proposed Regulation.

## Balance of Trade Impacts

It was not possible to develop a quantitative model of the international market for pulp and paper that could be used to analyze the trade impacts of the Proposed Regulation. Instead, important factors affecting each market are discussed, and the prospects for those products with significant price increases and involvement in international trade are assessed qualitatively.

## Structure of the Pulp, Paper and Paperboard Industry

The general structure of the industry was analyzed in terms of 26 product sectors. A single mill can have production in more than one product sector. Detailed descriptions of each of these product sectors is presented in Volume II of this report.

A number of important product sector characteristics were found to be associated with the overall production level. The small volume producers are: Glassine and Greaseproof, Cotton Fibre, Special Industrial, and Thin Papers. The median mill size for these sectors range from about 50 to 100 tons per day. They tend to be older mills, located near urban areas and in the Northeast or North Central regions. Many produce specialized products. Several suffer from competition from plastics or other papers. In general, productivity growth has been low, and expansion plans are minimal.

Medium volume paper producers are Solid Bleached Bristols, Uncoated Groundwood, and Bleached Kraft Paper. The median mill size ranges from about 420 to 550 tons per day. These mills tend to have somewhat newer capital stock and more widespread regional distribution than the smaller, specialty mills. Their productivity growth rates are moderate with some mills planning expansion.

Large volume paper producers are Uncoated Freesheet, Coated Printing, Unbleached Kraft Paper, Newsprint, and Tissue. The median mill size ranges from 140 to 890 tons per day. These firms tend to be publicly owned and multi-mill. The mills are generally new, with high productivity growth rates and large planned expansions.

Paperboard producers are grouped on the basis of furnish as well as size. Recycled material-based paperboard includes: Molded Pulp Products (small volume), Recycled Corrugating Medium and Recycled Linerboard (medium volume), and Recycled Foldingboard and Construction Paper and Board (large volume). Median mill size ranges from about 70 to 190 tons per day. Compared to virgin wood-based paperboard, recycled-based firms tend to have a higher degree of private ownership and, except for Construction Paper and Board, their economic future appears less promising. Recycled-based mills tend to be older, and to be located in the Northeast and North Central regions of the country, near their fiber suppliers.

Wood-based paperboard includes: Bleached Kraft Linerboard (small volume), Bleached Kraft Foldingboard and Solid Bleached Board (medium volume), and Unbleached Kraft Linerboard and Semi-Chemical Corrugating (large volume). The median mill size ranges from about 860 to 1,600 tons per day. These mills primarily are located in rural areas of the Southeast. They tend to be new, with high productivity growth rates and large expansion plans.

Only two pulp product sectors were considered in this study: Dissolving Pulp and all other Market Pulp. Dissolving Pulp is treated separately since it is a highly specialized product with uses that are not connected to the rest of the paper industry. These mills have a median size of about 640 tons per day, and primarily are located in the Southeast and the Northwest. They face decreasing demand, have experienced high productivity growth and do not plan to expand. Market Pulp is any other pulp, such as Bleached Kraft Pulp, which is not used in the production of paper or paperboard by the firm manufacturing it but is purchased by another firm. These mills have a median size of about 890 tons per day, and are located primarily in the Southeast. The age of the mill varies with the process used. Expansion plan data was not available.

Product sectors vary in terms of degree of integration from pulp to papermaking. For purposes of this economic analysis, mills are classified into three categories: integrated, nonintegrated and secondary fiber. In general, the degree of integration is related to the value of the end product. Mills producing low-price-per-unit products are usually integrated, while mills making specialized, high value products frequently are nonintegrated. Integrated mills are usually located in rural areas, while nonintegrated and secondary fiber mills tend to be located in urban areas.

This analysis divided the United States into five regions. While the Northeast has more mills than any other region, the Southeast has more capacity. Also, more investment has been taking place in the Southeast than in any other region.

The United States clearly dominates world production and consumption of pulp, paper and paperboard products. However, over the past several years, U.S. production as a percent of world production has been declining slowly. Given the size of our industry, our relatively low-cost timber supply, and current expansions, the U.S. can be expected to maintain its major role in world production levels.

Research and development has never been a major activity for this industry. On average, it allocates about 0.7 percent of its sales revenues to this area. Research funds are divided between process development, including pollution control, and product development. The most commercially attractive innovations in the future are likely to be those which reduce fiber requirements, effluent loads or energy requirements. However, new technology related to product development, such as fluff pulp, air layering, and supercalendaring recently have led to new products.

## Financial Profile

The Pulp, Paper and Paperboard Industry entered 1980 expecting a major downturn along with the rest of the U.S. economy. Data Resources, Inc. predicts a drop of 3.5 percent in total U.S. paper and board production in 1980, but expects the future to be very good. The general financial performance of paper and allied industries during the last several years has been better than that during the late 1960's and early 1970's.

One of the distinguishing characteristics of this industry is the high level of capital investment required. A majority of the capacity expansion has occurred at existing facilities as opposed to the building of greenfield mills, which tends to be more expensive. Much of this expansion has been financed internally.

Using data compiled by Standard and Poor's Corporation, the financial condition of various firms and the different subcategories are analyzed in terms of long-run, non-liquid asset ratios. Twelve firms which have high ratios of net income to total assets are compared with ten firms which have low ratios and seventeen small firms. The high ratio firms tend to be less dependent on paper sales than the low ratio firms, and are more likely to be producers of paper as opposed to board.

The high and low ratio groups have nearly the same ranking in terms of total sales. While a few of the small firms are clearly in financial trouble, small firms are not necessarily weak firms.

Subcategories were compared in terms of three ratios: working capital to total assets, investment in the past five years to fixed assets, and general, sales and administrative expenditures to cost of goods sold. Working capital as a percent of total assets tends to be highest for small and/or secondary fiber mills and nonintegrated mills. General, sales and administrative expenditures as a percent of cost of goods sold also tends to be high for mills producing highly differentiated products and for secondary fiber and nonintegrated mills, although this relationship is less strong. Investment over the last five years as a percent of fixed assets tends to be higher for integrated mills, with both large-mill and small-mill subcategories experiencing heavy investment.

## Pricing

This section addresses the question of how cost increases due to BCPCT and BATEA treatment requirements are likely to affect prices in the Pulp, Paper and Paperboard Industry. First, the historical relationship between costs and prices is reviewed, both for the industry as a whole and for smaller segments. The results emphasize the effect of capacity utilization rates on the ability to cover cost increases. Next, the effects of demand growth and elasticity of supply and demand on likely price impacts are discussed. Data on predicted end-use market growth and demand and supply elasticities in each product sector are used to assess expected price behavior under the assumption of competitive markets. Finally, the effect of the degree of competitiveness of markets, i.e. market structure, on pricing behavior is discussed, and the evidence for assessing the competitiveness of each product sector is examined. This evidence includes past behavior of costs and prices and quantitative descriptions of concentration for each product sector.

## Effluent Control Guidelines and Other Regulatory Costs

### Description of Regulations

Best practicable control technology currently available (BPT) effluent limitations are proposed for Wastepaper Molded Products, Nonintegrated Lightweight Paper, Nonintegrated Filter and Nonwoven Paper, and Nonintegrated Paperboard. The recommended technology for Wastepaper Molded Products is biological treatment, and the recommended technology for the other three is primary clarification. Costs for the Wastepaper

Molded Products can not be published due to confidentiality restrictions. For the other three subcategories, the technology is already in place and thus there are not additional costs to them.

The best available technology economically achievable (BAT) effluent limitations have become the national means of controlling the discharge of toxic pollutants. The proper application and operation of the technologies which form the basis of BPT effluent limitations were found to control chloroform and zinc. The other two regulated toxic pollutants discharged from Industry mills are trichlorophenol and pentachlorophenol. These can be controlled to trace levels by chemical substitution for slimicides and biocides containing trichlorophenol and pentachlorophenol without expensive end-of-pipe treatment.

The best conventional pollutant control technology (BCT) effluent limitations are established for dischargers of conventional pollutants from existing industrial point sources. This study analyzed four alternative options in addition to the Proposed Regulation.

The effluent limitations set by the Proposed Regulation are based on the levels attained by best performing mills in the respective subcategories. These limits apply to all subcategories for which the BCT cost-reasonableness test passes. For those subcategories which fail the BCT cost test (Nonintegrated Tissue Papers, Nonintegrated Lightweight Papers, Nonintegrated Filter and Nonwoven Papers and Nonintegrated Paperboard) the less stringent Alternative Option 1 forms the basis of BCT if it passes the BCT cost test. Alternative Option 1 effluent limitations are based on the technology upon which BPT is based for each subcategory plus additional in-plant production process controls. The only exceptions are the Dissolving Sulfite Pulp and Builders' Paper and Roofing Felt subcategories for which BCT is established at the BPT level because of the projected severe economic impact.

The new source performance standards (NSPS) effluent limitations for control of toxic and conventional pollutants are based on the application of production process controls to reduce wastewater discharge and raw waste loadings and end-of-pipe treatment in the form of biological treatment for all subcategories except Nonintegrated Tissue Papers, Nonintegrated Lightweight Papers, Nonintegrated Filter and Nonwoven Papers, and Nonintegrated Paperboard, where end-of-pipe treatment is in the form of primary clarification. The economic analysis of this regulation is incorporated into the analysis of the BCT regulations.

Pretreatment standards for existing sources (PSES) control the toxic pollutants trichlorophenol, pentachlorophenol, and zinc through chemical substitution. Chloroform is effectively controlled through application of biological treatment, the type of treatment most commonly used by publicly owned treatment works (POTWs).

Pretreatment standards for new sources (PSNS) is the same as for PSES.

## Past Expenditures on Environmental Pollution Control

Total environmental pollution control capital investment by the Pulp, Paper and Paperboard Industry peaked in 1975 at an annual level of 600 million dollars. Since then it has declined rapidly to an annual level of about 300 million dollars. Capital expenditures by the Industry for water pollution control increased from 1971 to 1975, leveling off at an annual rate of about 235 million dollars through 1977, and declining since then.

During the 1973-75 period, investment in pollution control as a percent of total investment was higher for the Industry than for any other major industry group except petroleum. After 1975 its ratio decreased rapidly, so that by 1978 it was close to the average for all manufacturing industries. The level of capital expenditures assigned to pollution control has been decreasing over time for all manufacturing industries.

## Future Expenditures on Environmental Pollution Controls

It is difficult to predict the level of capital expenditures that will be allocated by the Pulp, Paper and Paperboard Industry to pollution control other than water pollution over the next several years. There are many areas where new regulations are expected, but for which good cost estimates do not exist. These include:

Hazardous waste regulations promulgated under the Resource Conservation and Recovery Act (RCRA) (May 19, 1980).

National ambient air quality standards (NAAQS), under the Clean Air Act - to be reviewed by EPA for carbon monoxide, nitrogen dioxide, sulfur dioxide, and particulates in 1980 and 1981.

New source performance standards (NSPS) and national emission standards for hazardous air pollution from stationary sources (NESHAPS) to be developed by EPA under the Clean Air Act.

State implementation plans (SIP) and prevention of significant deterioration (PSD) plans to be developed by states for EPA.

Development of generic carcinogen policy by OSHA.

## Economic Impact Analysis

This section summarizes the results of the economic analysis for the Proposed Regulation. Results for the following parts of the analysis are included:

- Costs of Compliance: Number of mills requiring investment in each subcategory, average total annual cost per ton and total capital and total annual costs by subcategory and by product sector for existing and new sources;
- Demand/Supply: Effects of cost increases on price, output and contribution to capital in each sector;
- Capital Availability: Effect of control costs on present value of new capacity and ability of industry to finance investments in new capacity and pollution control out of current income;
- Mill Closure: Projected mill closures and associated employment impacts;
- Community Impacts: Indirect effects on employment and earnings; and
- Balance of Trade Impacts: Effects of price increases on international competitiveness of products with significant amounts of exports and imports.

BATEA costs are analyzed in each segment of the analysis. NSPS costs are analyzed in all segments except the mill closure and community impacts, since these apply to existing mills only. There are no costs associated with PSES or PSNS dischargers, so no impacts for these are analyzed.

### Costs of Compliance

Under the Proposed Regulation, total costs of compliance for capacity in place by 1983 are:

| | Millions of Dollars (1978) | |
|---|---|---|
| | Capital Costs | Total Annual Costs |
| Existing Sources | 1184.3 | 367.7 |
| New Sources | 174.8 | 62.5 |
| Total | 1359.1 | 430.2 |

This implies an average cost increase of $4.80 per ton for all pulp, paper and paperboard products. Table 1-1 shows total capital costs and total annual costs of compliance for existing and new sources by subcategory for capacity in place by 1983 as well as number of mills in each subcategory assigned costs. Subcategories with the largest percentage increases in production costs due to treatment costs are Market Bleached Kraft, BCT Bleached Kraft, Fine Bleached Kraft and Soda, Papergrade Sulfite, Miscellaneous Integrated Mills, and Deink (Tissue).

## Demand/Supply Analysis

Cost increases due to the Proposed Regulation are predicted to result in an overall average price increase of $4.10 per ton or 1.02 percent, a decrease in output of 480,000 tons per year or .63 percent, and a decrease in contribution to capital (revenues less variable costs) of $49.8 million per year or .42 percent. Table 1-2 shows the predicted impacts in each product sector.

Paper grades with relatively high price impacts are Newsprint (3.20 percent) and Glassine and Greaseproof (1.83 percent). Paperboard grades with relatively high price impacts are Bleached Kraft Linerboard (2.63 percent), Bleached Kraft Foldingboard (3.57 percent), and Semi-Chemical Corrugating Medium (2.48 percent). Dissolving Pulp has a price increase of 2.85 percent. Losses in output are generally less in percentage terms because demand for most products is inelastic. Impacts on contribution to capital are mixed, ranging from -3.72 percent for Bleached Kraft Foldingboard to plus 7.68 percent for Glassine and Greaseproof.

## Capital Availability Analysis

Two measures of the ability of the industry to finance investments in pollution control and new investment are used: the net present value of a unit of new capacity in each product sector; and the relationship of income after taxes, interest and depreciation in a given year to the amounts required for (a) bringing existing capacity into compliance with the Proposed Regulation, and (b) normal capacity expansion, including required pollution control costs.

Both in the Base Case and under the Proposed Regulation, negative net present values are projected for investments in new capacity in two product sectors: Bleached Kraft Papers and Bleached Kraft Linerboard. In the cash flow analysis, total cash flow in 1982 is $5.025 billion, capital costs of compliance are $1.259 billion, and costs of new capacity (including pollution control) are $1.733 billion. In the Base Case, annual cash flow is less than capital requirements in Bleached Kraft

**TABLE 1-1. Total Estimated Costs of Compliance for Existing and New Sources Under the Proposed Regulation**

(Millions of 1978 $)

| | Capital Costs | | Total Annual Costs | | Number of Mills With Costs |
|---|---|---|---|---|---|
| | BATEA | NSPS | BATEA | NSPS | |
| **Integrated** | | | | | |
| Dissolving Kraft | * | 0 | * | 0 | 2 |
| Market Bl. Kraft | 67.9 | 0 | 21.6 | 0 | 8 |
| BCT Bl. Kraft | 85.7 | 4.8 | 25.4 | 1.6 | 8 |
| Fine Bl. Kraft & Soda | 159.9 | 21.1 | 49.3 | 7.1 | 15 |
| Unbl. Kraft (Linerboard) | 67.4 | 26.6 | 20.5 | 8.4 | 13 |
| Unbl. Kraft (Bag) | 43.7 | 5.4 | 13.1 | 1.8 | 10 |
| Semi-Chemical | 34.4 | 14.7 | 11.5 | 4.9 | 15 |
| Unbl. Kraft and Semi-Chem. | 73.5 | 22.1 | 21.5 | 7.5 | 9 |
| Dissolving Sulfite Pulp | 0 | 0 | 0 | 0 | 0 |
| Papergrade Sulfite | 92.5 | 16.9 | 29.1 | 5.7 | 11 |
| Groundwood Thermo-Mechanical | * | 0 | * | 0 | 1 |
| Groundwood Coarse, Molded, Newspaper | * | * | * | * | 3 |
| Groundwood -- Fine Papers | 28.2 | 11.3 | 9.7 | 3.8 | 5 |
| Misc. Integrated Mills | 405.9 | 32.6 | 124.3 | 13.4 | 50 |
| **Secondary Fiber** | | | | | |
| Deink (Fine Papers) | * | 0 | * | 0 | 3 |
| Deink (Newsprint) | 0 | 4.6 | 0 | 1.9 | 0 |
| Deink (Tissue) | 21.5 | 2.5 | 7.9 | 1.0 | 7 |
| Tissue from Wastepaper | 3.6 | 0 | 1.4 | 0 | 8 |
| Paperboard from Wastepaper | 7.3 | 0.5 | 8.3 | 0.2 | 36 |
| Wastepaper Molded Products | * | 0 | * | 0 | 3 |
| Builders Paper & Roofing Felt | 0 | 1.5 | 0 | 0.6 | 0 |
| Misc. Secondary Fiber Mills | 8.0 | 4.6 | 2.8 | 2.8 | 3 |
| **Nonintegrated** | | | | | |
| Nonintegrated Fine Papers | 12.9 | 0 | 4.0 | 0 | 14 |
| Nonintegrated Tissue Papers | 1.7 | 0 | 0.4 | 0 | 6 |
| Nonintegrated Lightweight | 4.7 | 0 | 1.1 | 0 | 6 |
| Nonintegrated Filter & Non-woven | 0 | 0 | 0 | 0 | 0 |
| Nonintegrated Lightweight -- Electrical Allowance | 0 | 0 | 0 | 0 | 0 |
| Nonintegrated Paperboard | 0 | 0 | 0 | 0 | 0 |
| Misc. Nonintegrated Mills | 10.1 | 0 | 2.3 | 0 | 21 |
| Total | 1184.3 | 174.8 | 367.7 | 62.5 | 257 |

Source: Meta Systems estimates

*Suppressed due to confidentiality.

## TABLE 1-2. Summary of Demand/Supply Analysis Proposed Regulation

| | Average Percent Changes from Base Case, 1983-85 | | | Average Price Increase, 1983-85 (1978 $/ton) |
|---|---|---|---|---|
| **Paper** | Price | Output | Contribution to Capital | |
| Unbleached Kraft | .69 | - .75 | -1.30 | 2.00 |
| Bleached Kraft | .83 | -2.26 | -5.86 | 2.90 |
| Glassine | 1.83 | -5.94 | 7.68 | 16.00 |
| Spec. Industrial | .61 | - .48 | .92 | 5.80 |
| Newsprint | 3.20 | - .87 | 3.75 | 9.60 |
| Coated Printing | .49 | - .20 | -1.01 | 2.90 |
| Uncoated Freesheet | .80 | - .19 | - .51 | 4.60 |
| Uncoated Groundwood | 0 | 0 | -2.58 | 0 |
| Thin Papers | .20 | - .08 | -1.66 | 1.30 |
| Solid Bl. Bristols | .67 | - .24 | - .77 | 3.30 |
| Cotton Fibre | .08 | - .15 | - .16 | 1.20 |
| Tissue | .23 | - .01 | - .31 | 2.20 |
| **Board** | | | | |
| Unbl. Kraft Liner. | 1.86 | - .94 | .85 | 4.30 |
| Bl. Kraft Liner. | 2.63 | - .99 | 1.47 | 7.00 |
| Bl. Kraft Folding | 3.57 | -2.52 | -3.72 | 15.60 |
| Semi-Chem. Corr. | 2.48 | -1.76 | 1.63 | 5.50 |
| Recycled Liner | .18 | .01 | .57 | 0.40 |
| Recycled Corr. | 1.41 | 1.90 | 1.94 | 3.00 |
| Recycled Folding | .07 | - .08 | - .51 | .30 |
| Constr. Paper & Bd. | 0 | 0 | - .27 | 0 |
| Molded Pulp† | | | | |
| Solid Bl. Board | .72 | - .64 | - .36 | 3.30 |
| All Other Board | .18 | - .11 | -1.43 | 0.50 |
| **Pulp** | | | | |
| Dissolving | 2.85 | -2.09 | 4.04 | 10.40 |
| Market† | | | | |
| Overall Average | 1.02 | - .63 | - .42 | 4.10 |

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Source: Meta Systems estimates.
†No demand/supply model.

Papers, Newsprint, Bleached Kraft Linerboard, and Semi-Chemical Corrugating Medium. Under the Proposed Regulation, the following sectors also have cash flow less than capital requirements: Uncoated Groundwood, Bleached Kraft Foldingboard and Unbleached Kraft Linerboard. At the individual mill level, 56 mills have cash flow less than estimates BCT/BAT capital costs.

### Closure Analysis

Table 1-3 summarizes the results of the closure analysis for the Base Case and the Proposed Regulation. Fifty-seven out of a total of 587 mills are forecast to close in the base case. Seven more mills are predicted to close under the Proposed Regulation, and another four mills that were projected base case closures stay open, making net closures due to the Proposed Regulation equal to three. This occurs because indirect discharger mills or mills with low treatment costs benefits from the price increases brought about by mills with higher cost increases. The overall amount of capacity lost is 3.15 million tons per year in the Base Case, with a net gain of 210 thousand tons per year under the Proposed Regulation. This net increase is accompanied by a projected net increase of 600 jobs under the Proposed Regulation.

It is important to verify the forecast of base closures, because it is possible that overestimating the number of base closures could lead to an underestimation of closures due to treatment costs. The number of base closures seems high but is not out of line when compared with previous years or with projected market conditions in various sectors. According to API, 56 mills closed in the period 1970-75, 14 mills in 1976-77, and 9 mills in 1978-79. In comparison, our analysis covers the period 1978-85.

Market conditions in several product sectors make a number of closures likely. Typically, smaller, older nonintegrated mills will be vulnerable to a combination of significant increases in new integrated capacity and recession-weakened demand in the early 1980's. This situation should occur in Tissue, Coated Printing and Uncoated Freesheet, and Unbleached Kraft Linerboard. In addition, closures can be expected to be concentrated in the secondary fiber and nonintegrated mills because they will be caught in a squeeze due to market pulp prices rising faster than the wood prices faced by integrated mills.

### Community Impact Analysis

Table 1-3 also summarizes the results for direct and indirect impacts of closures on earnings and indirect impacts on employment. Under the Proposed Regulation, net direct increases in earnings are $36.3

TABLE 1-3. Summary of Closure and Community Impact Analyses

| | Major Subcategory Groups | | | |
|---|---|---|---|---|
| | Integrated | Secondary Fiber | Nonintegrated | Total |
| Base Case | | | | |
| Number Closures | 6 | 25 | 26 | 57 |
| Capacity Closed (1000 tons/year) | 1031 | 851 | 1269 | 3151 |
| Added Impacts of Proposed Regulation | | | | |
| Number of Closures | 1 | 5 | 1 | 7 |
| Number Reopenings | 1 | 2 | 1 | 4 |
| Net Capacity Closed (1000 tons/year) | -102 | 66 | -174 | -210 |
| Net Direct Jobs Lost | 0 | 250 | -850 | -600 |
| Net Direct Earnings Losses (Millions of 1978 $) | -12.0 | 4.4 | -28.7 | -36.3 |
| Net Indirect Jobs Lost | -400 | 600 | -3600 | -3400 |
| Net Indirect Earnings Losses (Millions of 1978 $) | -5.4 | 11.4 | -68.9 | -62.9 |

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Source: Meta Systems estimates.

million per year, increases in indirect earnings are $62.9 million per year, and total increases are $99.2 million per year. Net indirect increases in jobs due to the Proposed Regulation are 3400.

### Balance of Trade

For most product sectors, and all the important U.S. export sectors, the price increases resulting from the Proposed Regulations are relatively small. In addition, we can expect to continue to benefit from relatively low cost wood. Canadian mills are benefiting from a government grant program to help finance their modernization and pollution control programs, and Scandinavia is benefiting from the elimination of tariffs with the EEC. These, plus changes in exchange rates, are likely to have a greater impact on the U.S. competitive position than price increases due to the proposed pollution controls. Two product sectors which may suffer trade impacts because of their predicted price increases and degree of trade involvement are Dissolving Pulp and Newsprint.

### Limits of the Analysis

This section discusses the major limitations of the assumptions, methodology and results of the analysis. It also presents the results of a number of sensitivity analyses which test the robustness of the results of Section 7. It is organized into parts which parallel those of the methodology and results sections (2 and 7, respectively), i.e., costs of compliance and construction of supply curves, demand/supply analysis, capital availability, mill closures, community impacts, and balance of trade effects.

The part on costs and supply curves discusses the effects of real cost increases between 1978 and 1983-85 and the problems of aggregating production cost data for different grades within a product sector. The sensitivity of pollution costs to the value of the capital recovery factor and the mix of new and existing sources is examined. In general, cost and price increases are underestimated somewhat as real cost increases between 1978 and 1983-85 are not included. The effect of this on the results of the capital availability and closure analyses is not clear, however.

The discussion of the demand/supply analysis includes the implications of assuming competitive markets, the consistency of the results with long-run equilibrium, and problems of aggregation. The sensitivity of the results to alternative prices of substitute goods and alternative macroeconomic forecasts is examined.

Issues in the capital availability analysis include the reliability of capacity expansion costs and revenue estimates.

The part on the closure analysis focuses on the limitations of 308 Survey data, the reliance on a straight present value calculation, and the assumptions about real cost increases. The sensitivity of the results to the definition of salvage value, the treatment of transfer mills (i.e. those mills transferring their production to converting operations), and the price forecasts is examined. In general, the estimates of base closures show substantial variation, but those of added closures due to treatment costs are quite stable.

# Section 2

## The Economic Assessment Methodology

### Introduction

This section presents the methodology, assumptions and data sources used in the economic assessment of the effect of BCPCT and BATEA regulations on the Pulp, Paper, and Paperboard Industry. Figure 2-1 shows the major elements and information flows of the analysis. The main elements include the demand/supply analysis, which produces forecasts of price, output, contribution to capital and capacity utilization used in the rest of the analysis; the capital availability analysis; the mill shutdown analysis; the employment and community impact analyses which flow directly from the shutdown analysis, and the balance of trade analysis.

The diagram shows the four major sources of information used. The 308 Survey* provided financial and production data on 648 mills (based on 633 responses) out of approximately 700 pulp and paper mills in the United States. The technical contractor to the Effluent Guidelines Division, E.C. Jordan & Company, supplied information on the costs and characteristics of the pollution control equipment to be installed. Data from the 308 Survey and E.C. Jordan are central to the generation of the supply functions. Data Resources, Inc. (DRI) provided the econometric demand equations for the model, including the macroeconomic forecasts of certain exogenous variables, and forecasts of capacity expansion. Industry sources such as the American Paper Institute (API) and trade journals provided additional estimates of capacity expansion, as well as other information useful in making decisions at every step of the analysis.

This section also discusses the methodology and data used to calculate a capital recovery factor for the industry.

### Cost of Capital, Capital Recovery Factor

Before examining the elements of the analysis, this section begins with the derivation of the industry's cost of capital and the capital recovery factor (CRF). The cost of capital is used to determine the discount rate to be used in the present value analyses which form parts of the capital availability and shutdown analyses. It is also one parameter used to calculate the capital recovery factor. The capital recovery factor is used to calculate total annual costs, i.e., the sum of variable costs and an annual capital charge (defined below). Total annual costs are the basis for forecasting price increases, as discussed in the following part.

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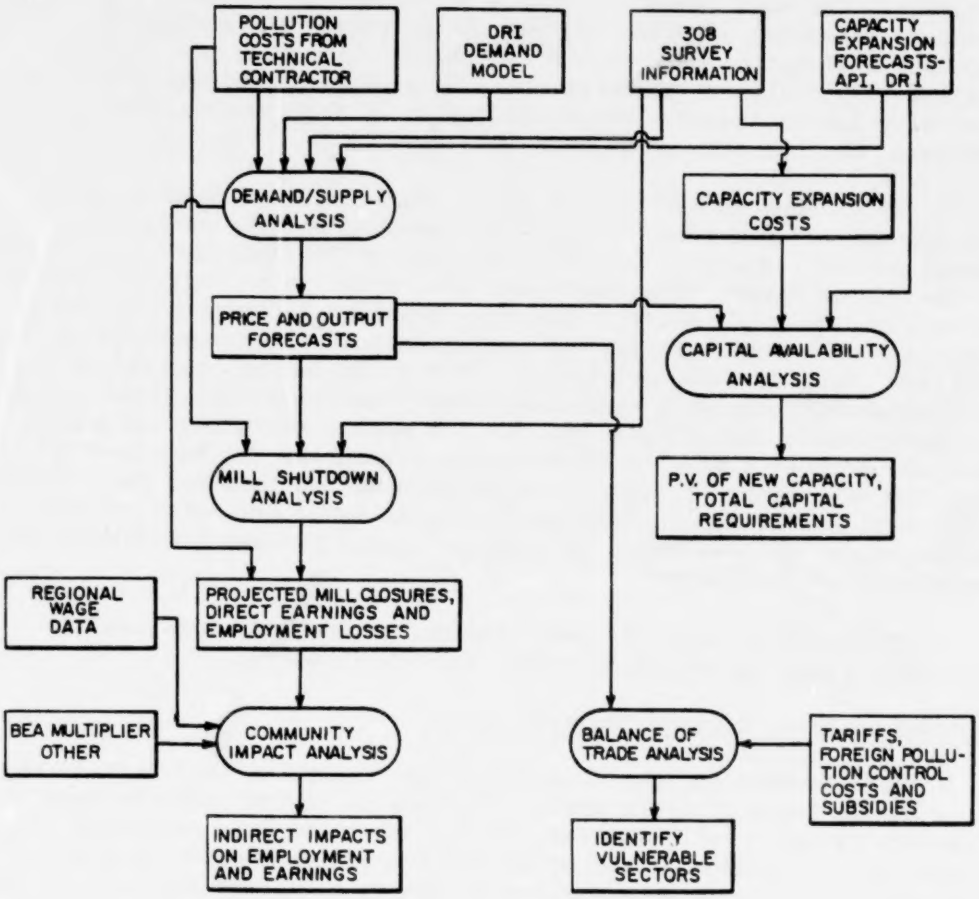
*This survey, also referred to as the 308 Financial Survey, is described in Appendix 2-A.

FIGURE 2-1. Overall Information Flows


POLLUTION COSTS FROM TECHNICAL CONTRACTOR
DRI DEMAND MODEL
308 SURVEY INFORMATION
CAPACITY EXPANSION FORECASTS- API, DRI
DEMAND/SUPPLY ANALYSIS
CAPACITY EXPANSION COSTS
PRICE AND OUTPUT FORECASTS
CAPITAL AVAILABILITY ANALYSIS
MILL SHUTDOWN ANALYSIS
P.V. OF NEW CAPACITY, TOTAL CAPITAL REQUIREMENTS
REGIONAL WAGE DATA
PROJECTED MILL CLOSURES, DIRECT EARNINGS AND EMPLOYMENT LOSSES
BEA MULTIPLIER OTHER
COMMUNITY IMPACT ANALYSIS
BALANCE OF TRADE ANALYSIS
TARIFFS, FOREIGN POLLUTION CONTROL COSTS AND SUBSIDIES
INDIRECT IMPACTS ON EMPLOYMENT AND EARNINGS
IDENTIFY VULNERABLE SECTORS

NOTE: RECTANGULAR BOXES DENOTE INFORMATION FLOWS.
OVAL BOXES DENOTE UNITS OF ANALYSIS.

The capital recovery factor (CRF) measures the rate of return that an investment must achieve each year in order to cover the cost of the investment and maintain net earnings, including depreciation and taxes. Stated another way, the capital recovery factor is the excess of revenues over variable costs, per dollar of invested capital, needed to cover the cost of borrowing, depreciation and net profit-related taxes, while preserving the market value of the firm's stock.

The formula for CRF used in the analysis is:

$$\text{CRF} = \frac{A\,(N,K_f) - td}{1 - t} \qquad (2\text{-}1)$$

where

N = lifetime of investment
$K_f$ = average after-tax cost of capital
$A(N,K_f)$ = annuity whose present value is 1, given N and $K_f$ $[K_f/(1-(1+K_f)^{-N})]$
d = depreciation rate
t = corporate income tax rate

The derivation of the formula is given in Appendix 2-D. The assumptions and data used to obtain values for the above variables are described below.

A single, industry-wide CRF equal to 22 percent has been used in our analysis. For a given investment, a firm's CRF will vary with their cost of capital and mix of financing. However, it was not possible to estimate CRF's mill by mill.

Average Cost of Capital

The cost of capital, $K_f$, is the average percentage return that suppliers of debt and equity demand. For firms which have more than one type of capital, $K_f$ is calculated as the average of the after-tax costs of debt and the costs of equity, weighted by the share of market value of each relative to the total market value of the firm. In equation form:

$$K_f = \sum^{4} K_i w_i \qquad (2\text{-}2)$$

where

$K_i$ = the average cost of that form of capital
$w_i$ = percentage share of that form of capital

The costs of debt and equity are measured by the current market value of outstanding debt and stock, rather than the original costs when the debt and equity were issued. The argument that projects should be evaluated using the weighted average cost of capital as the discount factor has been made elsewhere* and rests on several assumptions. Firms are assumed to have an optimal debt/equity ratio (or at least some preferred debt/equity ratio), to have already obtained that ratio, and to strive to maintain it over time. In addition, it is assumed that new projects do not alter the overall risk position of the firm. (A change in the risk level might result in a change in the debt/equity level.) Therefore, new projects, on average, will be financed with these same desired fractions of debt and equity.

Weights. In this analysis, four sources of capital were considered: common stock, preferred stock, corporate debt, and Industrial Revenue Bonds. The weights ($w_i$) were derived from data found in Forms 10-K, submitted annually by firms to the Securities and Exchange Commission. For these firms, on average, their capital was distributed as follows:

50.4% -- common stock
0.4% -- preferred stock
43.3% -- corporate debt
5.9% -- industrial revenue bonds

It was assumed that these large, publicly held firms were better able to raise money in the debt market, and thus less reliant on retained earnings to finance capital projects than smaller firms. Since these percentages were meant to reflect industry-wide conditions, the actual weights used reflected greater reliance on retained earnings (common stock) and less reliance on debt.

Cost of Debt. While many pollution control investments are financed with tax-exempt Industrial Revenue Bonds (IRB), the majority of debt financing is in the form of corporate bonds. These two types of debt are handled separately. Since firms often have more than one debt issue, it is necessary to calculate an average cost within a company as well as across companies. The following information on 56 bond issues by 27 pulp and paper companies was obtained from Standard and Poor's Bond Guide (January 1980):

1) yield to maturity
2) debt outstanding
3) closing price

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*See, for example, J. Fred Weston and Eugene F. Brigham, Managerial Finance (6th ed.), Dryden Press, 1978, Chapter 19.

First, the total market value of each bond issue is calculated as the bond price multiplied by the amount of debt outstanding. Second, the average cost of debt is calculated as a weighted average of the various values for yield to maturity, where the weights equal the ratio of the market value of each bond issue to the total value of debt. The average before-tax cost of debt for these companies is 11.03 percent. These values were taken as proxies for the cost of debt in the early 1980's when the actual investment decisions take place.

It is very difficult to get current prices of Industrial Revenue Bonds. There are not widely traded, and thus the prices are not included in the Standard and Poor's Bond Guide. In addition, since they are issued by a local authority, it is sometimes difficult to identify a specific issue as financing investments in the pulp and paper industry. Therefore, an alternative method is used to estimate the current costs of IRB debt. The Standard and Poor's Bond Guide lists IRBs with their rating and the company responsible for the lease rental payment. The size of each issue is not given. However, a simple average of these gives an average Standard and Poor rating of A. According to financial experts, interest rates on IRBs generally increase by about 25 basis points for each reduction in the Standard and Poor rating. Thus, if AAA IRBs are selling for 9 percent, AA bonds will sell for 9-1/4 percent and A bonds will sell for 9-1/2 percent. As of the beginning of 1980, interest rates on 30-year AAA IRBs were 7 percent. Thus we assume that the average before-tax cost of IRBs for the pulp and paper industry is 7.5 percent. Alternatively, according to an article by Peterson and Galper,* the average spread between taxable and tax exempt rates was 30.2 percent for the 5-1/2 year period ending June 1973. This would imply a cost for IRBs of 7.7 percent. Therefore, an estimate of 7.5 percent appears reasonable, especially since IRBs remain a relatively small share of capital for most pulp and paper companies.

Cost of Equity. A firm's cost of equity can be expressed in equation form as:

$$r = \frac{\varepsilon}{P} + g \qquad (2\text{-}3)$$

where $\varepsilon$ is the annual dividend, P is the stock price, and g the expected growth rate of dividends.** To estimate the firms' cost of equity, the following data were obtained from Standard and Poor's Stock Guide

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*G. Peterson and H. Galper, "Tax Exempt Financing of Private Industry's Pollution Control Investment",* Public Policy, Vol. 23, No. 1, Winter, 1975.

**See, for example, J. Weston and F. Brigham, op.cit.

(January 1980):

1) dividend yield;
2) closing price;
3) number of shares outstanding.

This information was collected for both preferred and common stocks. An estimate of the expected growth rate was obtained using data on production levels for the years 1979-1990 from the DRI model. The annual compound rate of growth for total paper and paperboard production was calculated to be 3.5 percent. Since this is an estimate of production, not sales or income, an inflation factor must be added in. Based on the DRI inflation projections for 1980-1990, an annual compound rate of inflation of 7.5 percent was calculated. Thus, the expected growth rate of dividends (g in the above formula) is 3.5 + 7.5 = 11.0 percent. (This assumes that real prices remain unchanged.)

Separate costs of capital were calculated for common stock and preferred stock. The yield to maturity on the common stock of 53 forest product companies is 5.2 percent, which yields a cost of equity of:

$$5.2 + 11.0 = 16.3$$

This is more accurately described as the cost of retained earnings. The cost of new issues of common stock is higher than the cost of retained earnings because of the flotation costs involved in selling new common stock. Since new issues are a very small proportion of a firm's capital, they are not included in our calculation of the overall weighted cost of capital.

Preferred stock is a hybrid between debt and common stock. Like debt, it carries a commitment on the part of the corporation to make periodic fixed payments. Thus, the cost of capital is equal to:

$$r = \frac{\varepsilon}{P} \qquad (2-4)$$

without an estimate of the expected growth rate of dividends.

Depreciation

Depreciation is the fraction of revenues set aside each year to cover the loss in value of the capital stock. The industry tends to use an accelerated form of depreciation whenever possible for income tax purposes. However, the more conservative assumption of straight-line depreciation is used here. As can be seen below, this results in a higher estimate of the CRF. Any bias resulting from this would be in the direction of increasing the return necessary to cover an investment.

There is a wide variety of opinions concerning the depreciable life of investments. The current Asset Depreciation Range as established by the Internal Revenue Service gives a useful life for capital assets in the pulp and paper industry of 10 years, with a range of 8 to 12 years. The DRI model uses 15 years. Arthur D. Little, Inc. (ADL),* in its studies of the pulp and paper industry, uses a weighted average of 18.5 years. This is based on a lifetime of 33 years for buildings and a lifetime of 16 years for equipment. For new investments by the industry in processing equipment, ADL used a 16-year lifetime. For tax purposes, industry will use as short a lifetime as possible. However, equipment will probably be useful for a longer period, since obsolescence does not appear to be as pressing a factor in this industry as in some others such as chemicals. Therefore, we have used a lifetime of 15 years as a conservative estimate in line with other similar studies.

### Tax Rate

The current federal corporate income tax rate is 20 percent on the first $25,000 of profits, 22 percent on the next $25,000, and 46 percent on all profits over $50,000. For this analysis, we assume that mills are paying an even 46 percent federal tax on all profits. A study by Lin and Leone** indicates that state and local income taxes are also a significant factor in pollution control investments. State corporate income tax rates may be as high as 9.5 percent. In their study, a weighted average of 7 steel-producing states yielded an average state corporate income tax rate of 7.55 percent. State income taxes, of course, are deductible expenses in computing corporate income tax. We assume a state corporate income tax rate of 8 percent. Deducting this figure before computing the federal income tax rate reduces the net effect of the 8 percent rate to about 4 percent. Thus, the overall effective income tax rate is approximately 50 percent.

### Sensitivity Analysis

Given the values for the costs of different kinds of capital, the CRF will vary with changes in the asset lifetime and changes in the relative weights of different kinds of capital. Table 2-1 shows that as a firm's dependence on retained earnings (common stock) increases, its weighted cost of capital ($K_f$) also increases. The weighted cost of capital varies from about 11 percent for firms deriving about

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*Economic Impacts of Pulp and Paper Industry Compliance with Environmental Regulations, Arthur D. Little, Inc., June, 1977.

**An Loh-Lin and Robert A. Leone, "The Iron and Steel Industry," in Environmental Controls, (Robert A. Leone, ed.), Lexington, MA: Lexington Books (1976), p. 70.

## TABLE 2-1 SENSITIVITY ANALYSIS OF CAPITAL RECOVERY FACTOR

| **Cost of Capital** (used in all versions):* | |
|---|---|
| Common Stock | 16.20 % |
| Preferred Stock | 4.17 |
| Corporate Debt (after-tax) | 5.96 |
| Industrial Revenue Bonds (after-tax) | 4.05 |

| | | | | | |
|---|---|---|---|---|---|
| **Weights*** ($w_i$) | | | | | |
| Common Stock | .504 | .555 | .600 | .675 | .700 |
| Preferred Stock | .004 | .004 | .004 | .004 | .004 |
| Corporate Debt | .433 | .392 | .348 | .282 | .260 |
| IRB | .059 | .054 | .048 | .039 | .036 |
| **Weighted Cost of Capital** ($K_f$) | 11.00% | 11.48% | 12.01% | 12.79% | 13.06% |
| **Life of Assets (N)** | 15 years | | | | |
| $A(N,K_f)$ | .139 | .143 | .147 | .153 | .155 |
| CRF | 18.3% | 19.4% | 20.5% | 22.1% | 22.6% |
| **Life of Assets (N)** | 10 years | | | | |
| $A(N,K_f)$ | .170 | .173 | .177 | .182 | .184 |
| CRF | 21.2% | 22.0% | 23.1% | 24.6% | 26.7% |

*See text for derivation

50 percent of their capital from retained earning to about 13 percent for firms deriving 70 percent of their capital from retained earnings. Likewise, a firm's CRF increases as the lifetime of the asset decreases. Assuming a 15 year life for assets, the CRF varies from 18.3 percent to 22.6 percent. For a ten year asset life, the CRF ranges from 21.2 percent to 26.7 percent. Therefore, 22 percent falls well within the range of likely values for an industry-wide CRF.

## Demand/Supply Analysis

### Overview

The core of the approach to estimating the impact of BCPCT and BATEA regulations on the industry is a microeconomic demand/supply analysis for each market (product) sector of the industry. The analysis produces a base case forecast of price, output, "contribution to capital" (revenues less variable costs) and capacity utilization for each product sector in the absence of new regulations. It also forecasts the effects of the costs of various treatment requirements on those variables. The approach assumes that individual product markets are competitive and that prices depend on the variable costs of the marginal (high cost) mills in the various sectors. Market or product sectors rather than subcategories are utilized because the relevant set of competing products depends on product type, not manufacturing process. The organization of the industry into product sectors corresponds closely to product groups used by API.

For each sector, supply curves are constructed from manufacturing cost and production data collected in the 308 Survey and pollution control cost estimates provided by the technical contractor. The supply curves explicitly relate mill subcategories, the basis for defining treatment costs, with product sectors, where the interaction of demand and supply takes place. Supply curves are generated for a base case with no additional pollution control requirements and for each of several control options. The supply curves for different years are adjusted to account for forecasts of capacity expansion through 1985.

The demand for each product sector is modeled using demand equations estimated by Data Resources, Inc. and linked with DRI's macroeconomic forecasts over the period of the analysis, 1979-85. This provides a demand forecast to match the capacity expansion forecasts on the supply side.

The interaction between supply and demand is modeled by solving the system of supply and demand equations for each product sector for equilibrium values of price, output, "contribution to capital" and capacity utilization for each year of the forecast period.

Figure 2-2 shows the information flows and stages of analysis which form the demand/supply analysis.

Figure 2-3 presents a more analytical picture of the relationship of the various elements of the analysis, and suggests some important implications of the methodology adopted. Quantity produced is measured along the horizontal axis and price and unit cost along the vertical axis. The base case assumes no new treatment requirements. Given demand curve DD and supply curve SS, market equilibrium implies price = P and output = Q. The excess of revenues over variable costs ("contribution to capital") is given by area CEP.

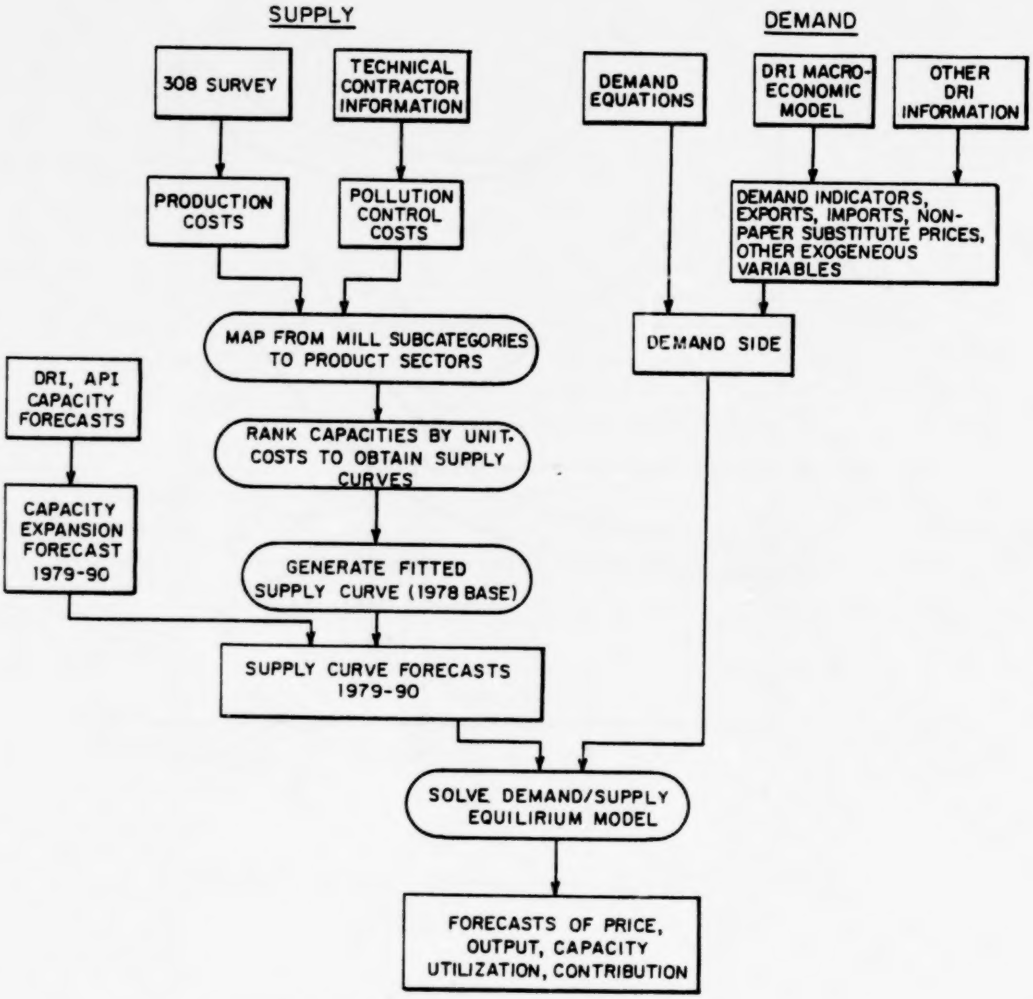
Let S'S' represent the industry supply curve with treatment costs. This yields a new equilibrium with price = P', quantity = Q' and contribution to capital = C'E'P'. A number of elementary but important observations flow from this analysis. First, as long as demand and supply are somewhat elastic, price will rise and output will fall. If supply is not perfectly elastic (i.e., if SS and S'S' are not horizontal) the price increase will be less than the cost increase for the original marginal producer (i.e., PP'<FE). Contribution to capital will either increase or decrease depending on the elasticity of supply and demand and the relative treatment costs of marginal and inframarginal producers. Also the imposition of controls will alter the relative profitability of mills in the industry depending on the size of the gap between SS and S'S' at various levels of output.

The resulting price and cost changes are inputs to the individual mill closure analysis and subsequent employment and community impact analyses. Price and contribution to capital also are used in the capital availability analysis. All of these factors highlight the advantage of being able to determine the effect of treatment costs on the entire supply curve, not just at the margin. Changes in cost and price are also inputs to the balance of trade analysis.

## Development of Supply Curves

The demand/supply methodology assumes an essentially competitive short-run market structure where price is determined by marginal variable cost. In this case the product sector supply curve is the marginal cost curve obtained by horizontally summing the marginal cost curves of individual mills. By definition, the marginal cost curve shows the incremental cost of an increase in output. In general, marginal cost and average cost for an individual mill will vary with output, as shown in Figure 2-4. However, if marginal variable costs of a mill are constant over a fairly wide range of capacity utilization, they will be roughly equal to average variable costs. Therefore, data for average variable costs from the 308 Survey are taken as an approximation of that mill's marginal variable costs. Figure 2-5 shows the supply curve implied by this approximation.

FIGURE 2-2. Demand/Supply Analysis


SUPPLY
DEMAND
308 SURVEY
TECHNICAL CONTRACTOR INFORMATION
DEMAND EQUATIONS
DRI MACRO-ECONOMIC MODEL
OTHER DRI INFORMATION
PRODUCTION COSTS
POLLUTION CONTROL COSTS
DEMAND INDICATORS, EXPORTS, IMPORTS, NON-PAPER SUBSTITUTE PRICES, OTHER EXOGENEOUS VARIABLES
MAP FROM MILL SUBCATEGORIES TO PRODUCT SECTORS
DEMAND SIDE
DRI, API CAPACITY FORECASTS
RANK CAPACITIES BY UNIT COSTS TO OBTAIN SUPPLY CURVES
CAPACITY EXPANSION FORECAST 1979-90
GENERATE FITTED SUPPLY CURVE (1978 BASE)
SUPPLY CURVE FORECASTS 1979-90
SOLVE DEMAND/SUPPLY EQUILIRIUM MODEL
FORECASTS OF PRICE, OUTPUT, CAPACITY UTILIZATION, CONTRIBUTION

NOTE: RECTANGULAR BOXES DENOTE INFORMATION FLOWS.
OVAL BOXES DENOTE UNITS OF ANALYSIS.

FIGURE 2-3. Shift in Supply Curve Due to Treatment Costs

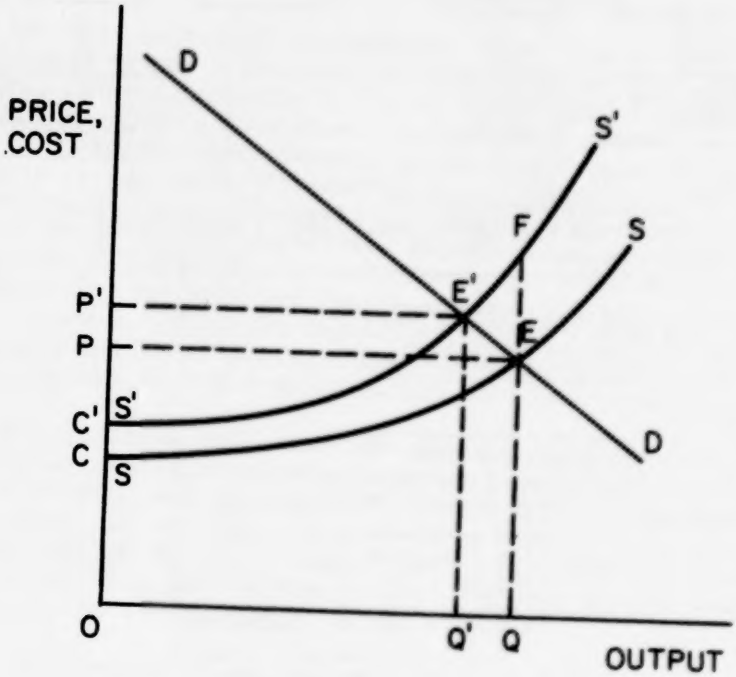


FIGURE 2-4. Example of Marginal Cost and Average Cost Curves

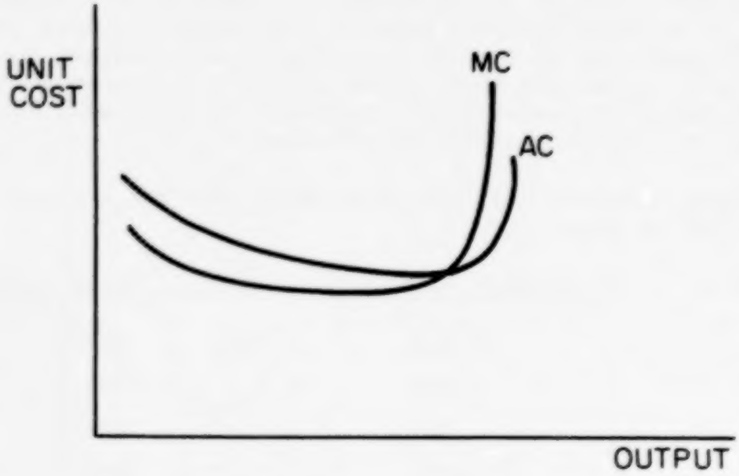
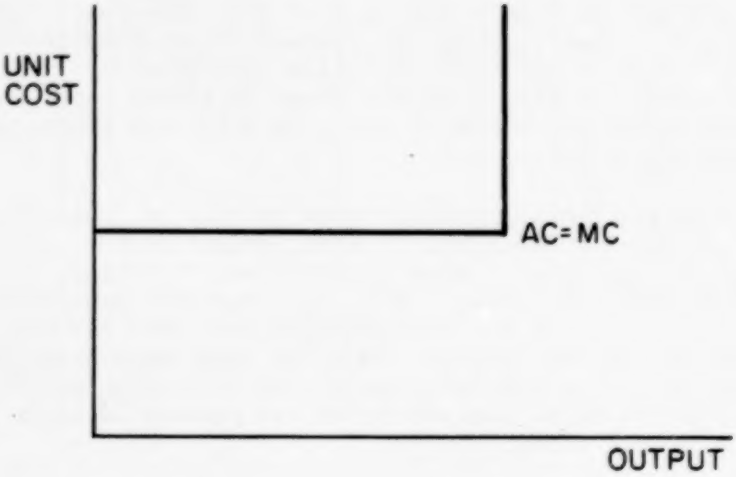


FIGURE 2-5. Example Where Marginal Cost Equals Average Cost



An estimate of the supply curve for the entire sector can be obtained by ranking all mills manufacturing a given product in terms of unit cost, and then pairing the unit cost of a given mill with the cumulative production of all mills with unit costs less than or equal to that mill's. This is the procedure followed in this study. Although the curve so obtained strictly equals the industry supply curve only under the assumptions of perfect competition and constant marginal cost for each mill, we believe that it represents a good approximation even if these assumptions are relaxed somewhat. The following example illustrates the curve construction procedure.

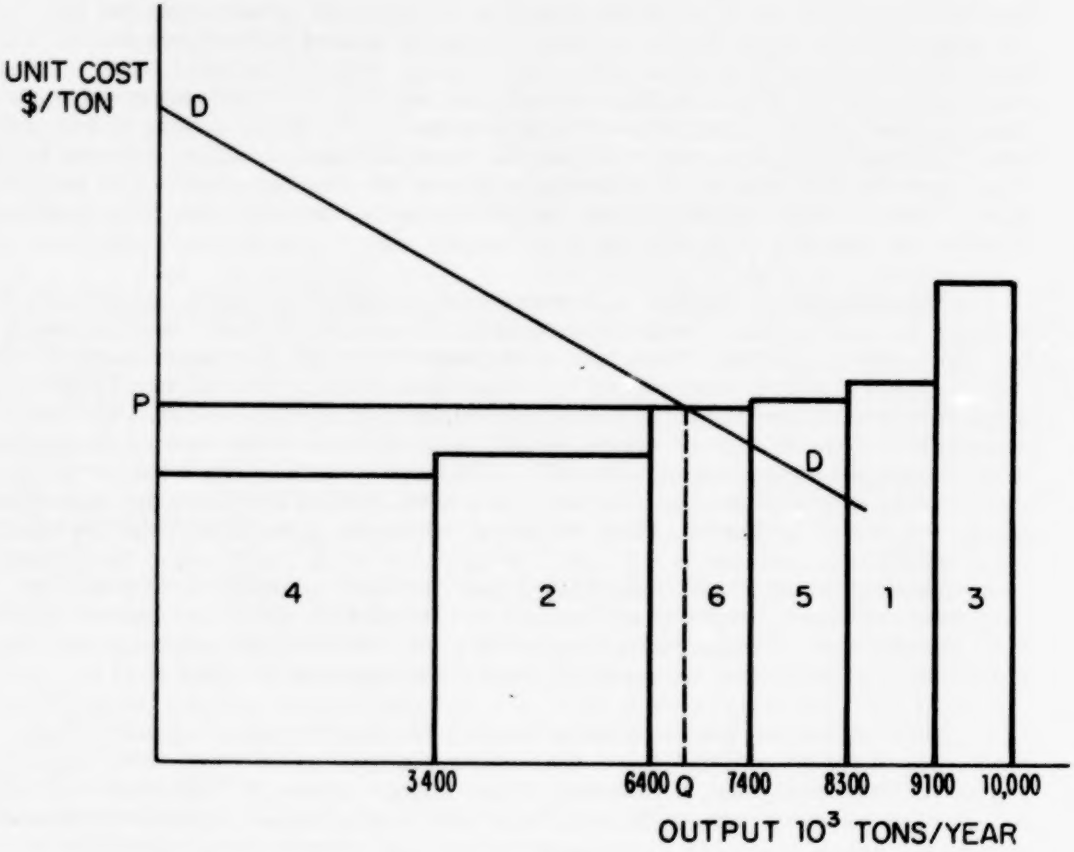
Example. Suppose the individual mill data for a given product sector are as follows:

| Mill | Production cost, $/ton | Output, 1000s tons/year |
|---|---|---|
| 1 | 210 | 800 |
| 2 | 180 | 3000 |
| 3 | 260 | 900 |
| 4 | 175 | 3400 |
| 5 | 205 | 900 |
| 6 | 200 | 1000 |
| | | (total = 10,000) |

Mill #4, being the lowest-cost producer, forms the first step on the curve with unit cost = 175, production = 3400. Mill #2 is the next lowest cost producer; its incremental output adds 3000 to the accumulated production, with a unit cost of 180. The rest of the curve is constructed similarly, until all production is accounted for, with the highest cost producer being the point (260;10,000). This process results in a step function like that shown in Figure 2-6. The length of each step is the production of that one mill, and the height of the step is that mill's unit cost.

In practice, the approach proceeds roughly as outlined above; with a supply curve constructed for each product sector. First, all of the mills that produce a given product, say Newsprint, are selected from the 308 Survey data base. Next, unit variable manufacturing cost is determined by summing the questionnaire responses for the individual cost components for that product: wood and pulp, chemicals, labor, energy, and other, and then dividing by the mill's output of that product. This is the basic step of the transformation of costs from subcategory to product sector.

FIGURE 2-6. An Example of a Constructed Supply Curve



The structure of the supply curve has some implausible implications. Suppose the intersection of the demand curve (DD) and the supply curve yields price P and quantity Q as in Figure 2-6. The figure implies that all mills with unit costs below that of mill 6 operate at full capacity, while mill 6 absorbs all the slack, and mills with higher costs do not operate at all, which is not realistic.* Nevertheless, the use of average costs gives a picture of the cost structure within a given product sector. Since high cost mills have the greatest variability of output, this should give a reasonable approximation of the shape of the supply curve.

Another limitation of the procedure is that it assumes that demand and supply in the entire product sector is cleared by a single price. In many markets, especially papers, there is a significant variation in quality and characteristics among subgrades, and prices will vary correspondingly. Therefore, producers that appear to have high costs may produce higher quality products with higher prices. Using a single price could distort the relative profitability of different mills. There is less harm on the demand side because prices of similar grades can be expected to move together. The implications of this problem are discussed further in Section 8 in the part on supply curve construction.

Standardizing Costs. All costs are adjusted to first quarter 1978 dollars to agree with the pollution control costs provided by the technical contractor. To do this, all cost data from 308 responses must be inflated/deflated to correspond to this fixed base. The ends of the accounting base years in the 308 responses vary from January 1976 to December 1978. To adjust these costs, approximate deflators of two sorts were developed. The first type are deflators directly applicable to specific products, as obtained from DRI time series for average operating costs for these products. For products where no such direct deflators were available, estimates of cost changes for each input were developed, covering wood, pulp, and secondary fiber, labor, chemicals, and energy. Separate regional cost factors were also developed for each input. In both cases, the time period selected for adjustment was based on the midpoint of the year-long accounting period as reported by the mill.

No further adjustments were made to Survey costs to account for real (constant price) input cost increases between 1978 and 1983-85, the period of the analysis. Although forecasts of costs of the various input categories are available, it was felt that using these forecasts directly would overstate the cost increases because of process changes mills would make in response to higher costs. Nevertheless, it is expected that real production costs will increase 5 to 15 percent over this period.** The implications of not taking this into account are discussed in Section 8.

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*In the analysis, reported production was used as a proxy for capacity to construct the supply curves, since production costs were only available for that amount. This tends to understate capacity somewhat. However, this is compensated for in the calibration of the supply curves described below.

**DRI Pulp and Paper Review, June, 1980, passim.

Functional Form of the Supply Curve. Both for reasons of confidentiality and because of the cumbersome form of the step functions derived by the above procedure, the calculated values of unit costs and cumulative production are used to estimate econometrically a smooth supply function which approximates the step function. The fitted curve is the one used in the demand/supply analysis. It has the general form:

$$c = f(q)$$

where

$c$ = unit cost
$q$ = cumulative production

A variety of functional forms were investigated for each product sector and the choice of which to use in the demand/supply analysis depended on such criteria as reduction in sum of squares, significance of coefficients, and standard errors of estimate. Appendix 2-E gives the functional forms used and the coefficient estimates of the fitted supply curves.

Calibration of Supply Curve to Base Case. Because the survey data on production are taken from several different years and coverage was not complete, the supply curve generated by the above procedure does not correspond to actual supply conditions in any particular year. Specifically, the cumulative production obtained from the curve corresponding to the price of a product in 1978 is not necessarily equal to reported output of that product in 1978. (In most cases, cumulative production at the 1978 price is within ten percent of actual 1978 production, but usually lower. In a few cases it is higher.)

In order to calibrate the demand/supply model for each sector, the estimated supply curve is shifted right or left so that it is consistent with the 1979 price (in 1978 dollars) and level of output.* Strictly speaking, this procedure assumes that the "unobserved" capacity has variable costs equal to the y-intercept of the fitted supply curve. In practice, as long as the unobserved capacity has variable costs less than those of the marginal high-cost mill, the calibration will not affect the shape of the supply curve in the region of its intersection with the demand curve. Therefore, it will not affect the forecast of price and output in the demand/supply analysis.

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*1979 is the most recent year for which annual information is available. Therefore, there is no need to start with 1978 levels and "forecast" 1979 levels. This approach is identical to that used to model capacity expansion in subsequent years. (See below.)

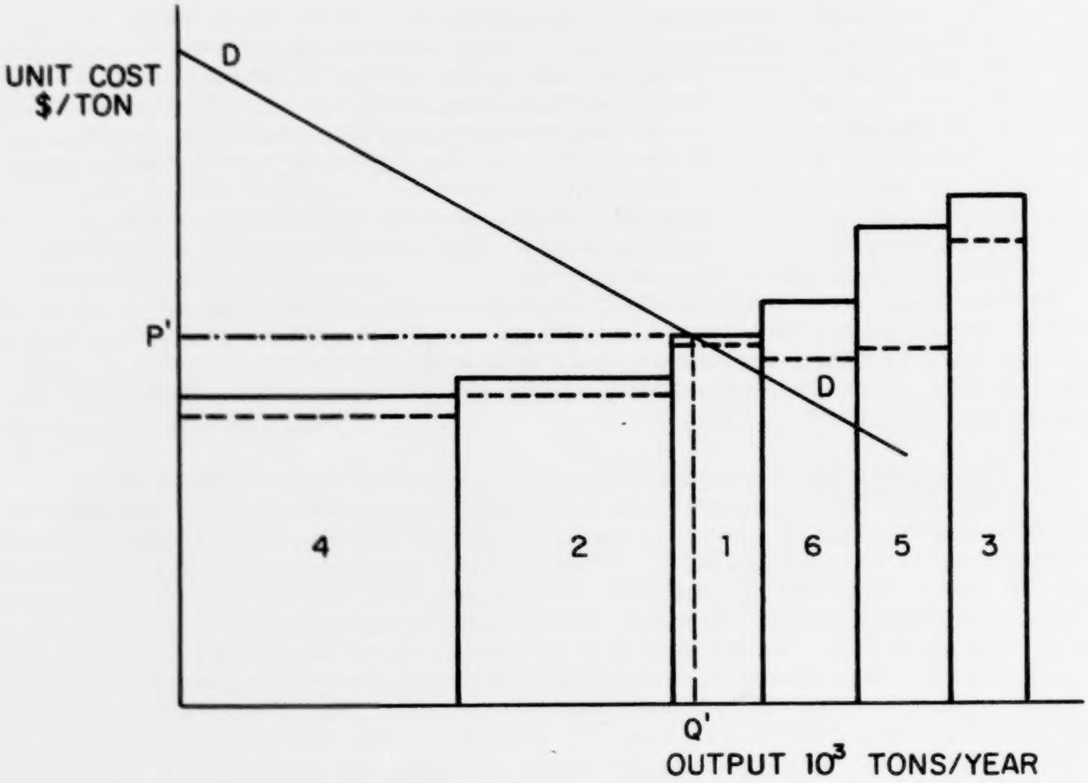
Inclusion of Pollution Control Costs. Pollution costs for several levels of control were determined by the technical contractor for individual mills and for the basic divisions of subcategory. Generally, one level of production process controls and two levels incorporating end-of-pipe treatment were considered. Costs were calculated for capital, operation and maintenance (O&M) and energy on an annual basis. Where appropriate, regional factors modifying these costs were developed. The actual pollution control options and their associated costs are described in Sections 6 and 7.

The treatment costs added to the supply curve are total annualized unit costs which include capital charges (investment costs multiplied by the CRF), as well as variable costs. This is because the decision to install pollution control equipment and remain operating is a long-run decision. We assume that firms can correctly predict future trends so that only those which expect to recover at least the total costs of their pollution control system will stay open. This approach ensures that the marginal producer remaining open will recover total treatment costs.

The procedure for estimating the supply function including pollution control costs is to divide the costs of a specified level of pollution control for each mill, by the mill's capacity to obtain a treatment cost per ton. This unit cost is then added to the unit variable manufacturing cost of that mill. This implies that a mill's treatment costs are allocated across its various products on an equal per ton basis. The mills are reranked by unit cost and the supply curve is reestimated using these new cost figures. The new curve will shift upwards, reflecting the increased costs of additional pollution control. Note that if a mill had inframarginal unit costs before treatment, but has unit costs greater than the marginal mill after treatment, its position in the supply curve will shift to the right of the marginal mill. For example, Figure 2-7 shows the supply curve from Figure 2-6 after pollution costs have been added. In this case, the cost rankings of mills #1, #5, and #6 have switched.

The Adjustment of the Supply Functions to Account for Capacity Expansion. The supply functions were generated using the data on production, capacity, and costs available at the time of the 308 Survey. However, because we forecast supply through 1985, and because the supply curve will change shape with additions of new capacity and retirement of old capacity, these supply curves must be adjusted to account for capacity expansion.

FIGURE 2-7. Supply Curve Resulting from the Reranking of Mills with Treatment Costs



NOTE: HORIZONTAL DASHED LINE (---) SHOWS PRE-CONTROL UNIT VARIABLE COST

HORIZONTAL SOLID LINE (—) SHOWS UNIT VARIABLE COST PLUS TOTAL ANNUAL POLLUTION CONTROL COST

There are several sources of information on current and future capacity. The capacity figures published by the American Paper Institute (API) are generally considered to be the most reliable of those publicly available. The responses to the 308 Survey also provide information on current capacity and expansion to which the mills are committed. Most of this expansion is to be on stream by 1981. Current API figures include probable expansion through 1982. The 308 Survey and API are in reasonably close agreement on capacity, both current and planned, to 1981.

DRI forecasts future capacity through 1985. They base their current capacity on API data, and use API estimates for expansion through 1982. After 1982 their forecast of capacity is based primarily on creating the capacity needed to meet the demand forecast by the DRI model. An additional source of information on future expansion is the historical trend for each product sector. The projection must take into account the cycles in investment which appear to be common for several product sectors. Through 1982 we use the API estimates of capacity. Estimating expansion beyond 1982 is more difficult because firms do not have definite plans that far in advance. The construction of a complete investment model is particularly difficult in an industry like pulp and paper, where expansions involve large sums of money and occur infrequently. Rather than treating investment as an endogenous variable, we have chosen to estimate future capacity based on API and DRI forecasts. These estimates are described in Section 7.

Two checks are imposed on these estimates of capacity expansion to ensure that they are reasonable. The first is capacity utilization. To a certain extent, output can be increased by making greater use of current capacity. According to API estimates, in 1977 there were 27,381,000 tons of paper produced, with a capacity of 29,859,000 tons. Thus, the overall capacity utilization rate was approximately 91.7 percent. Included in the measure of capacity is an allowance for normal maintenance, grade changes, and other downtime. Therefore, it is possible to have a capacity utilization rate of more than 100 percent, but only for a short period. On the other hand, if the capacity utilization factor declines sharply, there is reason to conclude that the capacity estimate is too high. This criterion was used to evaluate the results of the demand/supply analyses using initial capacity expansion estimates. In some cases, the capacity forecasts were revised if the changes in capacity utilization implied by the demand/supply forecasts varied significantly and/or were inconsistent with other information about the likely prospects for that product factor.

A second check is the profitability of investments in new capacity. The present discounted value of the excess of price over variable cost per ton after tax can be taken as the value of the investment. If this value exceeds the unit costs of new capacity from the 308 Survey, then the capacity expansion forecast is profitable. The methodology is discussed more fully in the section on capital availability analysis.

To actually model the effect of capacity expansion on the fitted supply curves, it is assumed that new capacity has unit variable costs equal to the minimum of that for existing capacity. Therefore, the addition of new capacity can be represented simply as a rightward shift of the existing cost curve, with unit costs of new capacity equal to the y-intercept of the original cost curve. This adjustment is exactly analogous to that used to calibrate the supply curve to the 1979 base period.

Consider the example in Figure 2-8. Figure 2-8a represents a product sector supply function as it might appear in 1979. If five units of additional capacity were projected for 1980, the supply curve would be shifted as shown in Figure 2-8b; i.e., the new capacity would come in as low variable cost production onthe left end of the supply function. If additional capacity was expected to come on-stream in the following year, it would be introduced in exactly the same fashion.

It should be noted that this assumption about variable costs of new capacity could be relaxed without affecting the results of the demand/supply analysis. As long as variable costs are less than the variable costs of the marginal existing mill, the intersection of the demand and supply curves is unaffected. Therefore, price and output changes due to treatment costs will not be affected either. However, relaxing this assumption does affect the amount of "contribution to capital" available for capacity expansion. Therefore, the capital availability analysis must be examined for sensitivity to this factor.

Supply functions are prepared in this manner for individual product sectors with and without pollution controls for each year from 1978 to 1985.

Total Cost of Compliance. The capacity expansion forecasts are also used to predict total costs of compliance to the Proposed Regulation for capacity in place by 1983. Costs of compliance for mills in place in 1978 are taken directly from the sums of treatment costs estimated for mills in the 308 Survey. The expansion forecasts can be used directly to calculate costs of compliance by product sector for mills in place by 1978. To compute costs by subcategory, expansion forecasts

FIGURE 2-8. Modeling Capacity Expansion Using the Product Sector Supply Curves

FIGURE 2-8a. Supply Curve in 1979

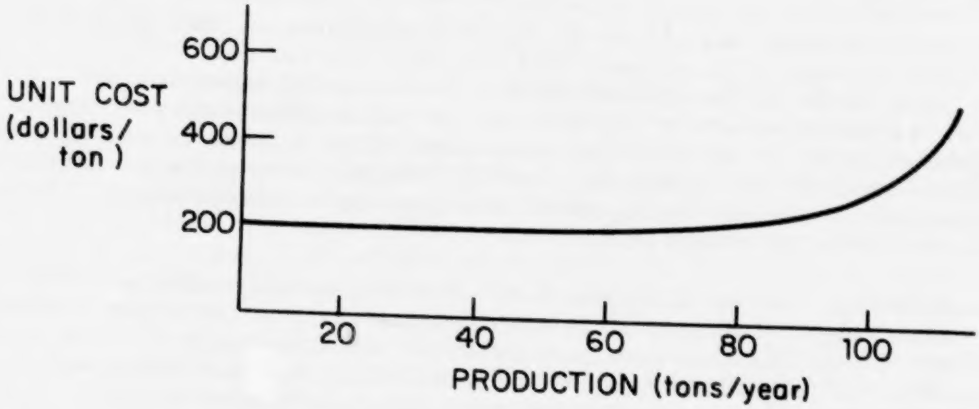
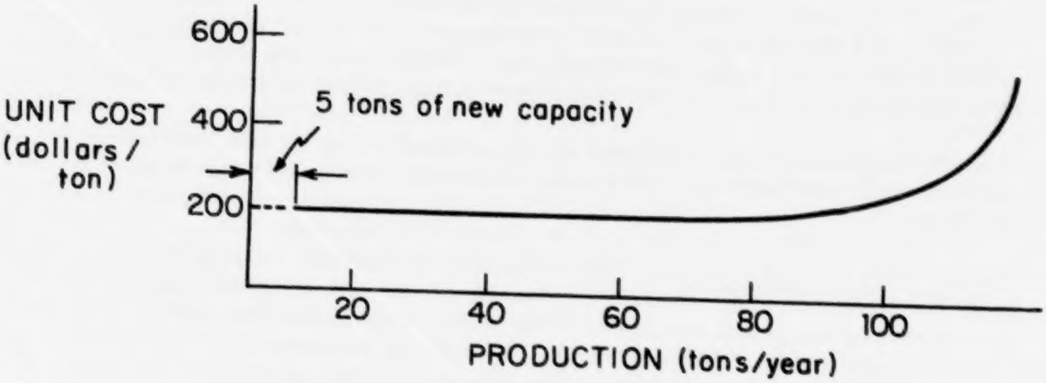


FIGURE 2-8b. Supply Curve in 1980 with Five Units of New Capacity



for each subcategory must be developed based on the product sector forecasts. First, an expected mix of subcategories corresponding to expansion in each sector was estimated. It was assumed that expansion after 1978 in each sector would contain the same fractions of integrated subcategories as found in the 308 Survey. Only a small increase in nonintegrated capacity is predicted.*

Starting in 1982, capacity increases due to "greenfield" mills or major alterations of existing plants are assumed, subject to NSPS standards. Thus it is necessary to predict what fraction of new capacity would be classified as a new source. This was done using information on installation of new machines in API's capacity forecasts and planned capacity increases in existing plants from the 308 Survey. These estimates are very uncertain. Therefore, the effect of assuming a different mix of new capacity is examined in the sensitivity analysis in Section 8.

## Demand Side Analysis

This section outlines the methodology used to model demand for pulp and paper products. It includes a discussion of general factors affecting demand in the industry, the structure of the equations making up the model, the results of the econometric estimation, and the macroeconomic forecast which drives the demand side of the demand/supply model.

Factors Affecting Demand. Demand for specific products within the industry exhibits considerable variety, since each product has its own unique characteristics. The economic and technological trends affecting demand for the twenty-seven product sectors that have been defined for the industry are summarized in the product profiles in Volume II. Some product sectors have been severely affected by the penetration of substitute materials into their traditional markets. Examples of this trend are the substitution of polyethylene bags for Bleached Kraft bags, of plastic film for Glassine and Greaseproof paper, of plastic containers for Molded Pulp products, and of plastic bottles for Solid Bleached Milk cartons. Other product sectors have not succumbed to penetration. For example, most Unbleached Kraft papers have superior packaging properties and consequently have maintained market shares.

Technological change in end use markets has affected some products. Demand for Solid Bleached Bristols is down since there is increased use of computer magnetic tape rather than cards. Uncoated Freesheet use, on the other hand, has grown due to the burgeoning need for business forms and paper for computers and copying machines.

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*This is because most new expansion does occur in integrated mills and because doing so automatically accounts for the increase in market pulp capacity that must, for consistency, accompany increase in nonintegrated capacity.

Technological changes in product production have improved demand in some sectors such as Newsprint, Uncoated Groundwood Paper, and very recently, Tissue, by improving product characteristics and therefore consumer acceptance.

The demand for each product is linked to the level of activity of particular sectors of the economy. For example, Special Industrial Papers demand follows overall industrial production, and Coated Printing Papers demand is related to the level of advertising in the U.S. Some products are also affected by national policy. The future use of the various recycled paperboards, for instance, will be influenced by national recycling policies.

Demand Model. Because most pulp and paper products are internationally traded, an analysis of demand must take into account both domestic and foreign demand and supply for a given product. The basic identity is:

Apparent Consumption = Shipments + Imports - Exports (2-5)

Shipments, i.e., domestic production, are the supply side of our model. Forecasting equations for imports and exports have been developed by DRI. In most cases, DRI's forecasts of exports and imports are taken as exogenous to the demand/supply models used in the present analysis, since their magnitudes are relatively small. (Dissolving Pulp is the exception.)

In the next step of the analysis, apparent consumption is analyzed into two components, actual consumption and inventory changes. In equation form:

Apparent Consumption = Consumption + Inventory Change (2-6)

This reflects the fact that consumers of paper and board products buy them to add to their inventories, as well as consuming them immediately for their given "end-use". Because inventory demand tends to be very volatile, it is preferable to separate it out and focus on the underlying end-use demand, i.e., actual consumption. Actual consumption is more stable and reflective of long-term effects of demand such as substitution and technological change. Not doing so would tend to overestimate the price elasticity of demand.

Lastly, in DRI's estimation approach, actual consumption is analyzed as the product of an "end-use factor" (EUF) and a "demand indicator" (IND). In equation form:

$$\text{Consumption} = \text{EUF} \times \text{IND} \qquad (2\text{-}7)$$

One can think of the demand indicator as an index which measures the effect on demand (consumption) of the size of the end-use consumption market while holding price and other factors constant. In the case of consumer Tissue, for example, an obvious candidate for a demand indicator would be the number of households in the U.S. Everything else equal, one would expect a doubling in the number of households to double the demand for consumer Tissues. In economic terms, the demand indicator represents shifts in the demand curve. In other cases, the demand indicator might be the index of production of the end-use industry. The choice of a demand indicator for a particular product sector depends on which macroeconomic variable best correlates with the size of the end-use sector.

Several product sectors are represented by more than one demand indicator because components of their demand are experiencing different market trends. Each demand indicator is weighted by the share of that component of total demand. For instance, demand for Coated Printing Paper has three major components. Demand for the smallest -- coated one-side paper -- is declining because of substitution by plastics. However, demand for the two types of coated two-side paper is growing, resulting in an overall increase in demand for the sector.

Conversely, the end-use factor can be thought of as the demand of an average unit of the end-use sector. In the case of tissues this would be a single average household. In some other sector it would be a unit of production of the end-use industry. Therefore, the end-use factor captures all other factors affecting demand (price, substitute price, technological change) except the size of the end-use sector. It is the demand curve "normalized" to a unit of the end-use sector. Multiplying the end-use factor (demand per end-use unit) by the demand indicator (number of end-use units) gives us back the total demand of the end-use sector, which, in equilibrium, equals actual consumption.

End-Use Factor Equations. DRI's approach is to estimate econometrically the end-use factor equation. Given time series for consumption and the chosen demand indicator, equation 2-7 yields a time series of the end-use factor. This end-use factor is then regressed against the appropriate own and substitute price series and other independent variables to obtain the coefficient estimates for the equation.

A typical end-use factor equation has the following form:

$$EUF_t = C + L(PQ_t/PD_t) + L(PQ_t/PS_t) + L(X_t) \qquad (2\text{-}8)$$

where

EUF = end-use factor
C = constant term
PQ = price of paper grade
PD = GNP deflator or other price index
PS = price of substitute good
X = other independent variables, e.g., time or proxy for technological change
L = lag operator (e.g., $L(X_t) \equiv \sum_{i=0}^{n} a_i x_{t-i}$)
t = time subscript

The constant term captures the "exogenous" component of demand. The second term in equation 2-8 measures the effects of changes in the real price of the paper grade, the third term measures the effect of relative changes in own and substitute prices, and the fourth term captures the effects of othe exogenous variables on demand. Lags on most price terms range from four to eight quarters.

In most cases, the end-use factor equations are estimated with quarterly data. In these cases quality is always a function of lagged relative price (not current price). This form makes them awkward to use in the demand/supply analysis bacause the elasticity of demand in the current quarter is zero. However, because the supply curves are based on annual data, it was necessary to convert the demand curves to an annual basis to make them compatible.* As a result of the annualization procedure, demand becomes a function of current as well as lagged price. This is because the lagged price terms for the most recent quarters are allocated to the current year when the aggregation from the quarterly to yearly basis is made. (See Appendix 2-C for details.)

Insufficient data were available to estimate end-use factor equations for three sectors: All Other Paper, Molded Pulp, and Market Pulp (except Dissolving Pulp). Problems include the multiplicity of different products included in these sectors and the difficulty of identifying demand indicators and obtaining price series. Analysis of the demand for Market Pulp is further complicated by the wide substitutability among different grades. As a result, demand/supply analyses could not be done for these sectors.

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*The annualization procedure is described in Appendix 2-C. As noted in the appendix, the annualization is an approximation requiring several simplifying, but not overly restrictive assumptions. An example and test of the procedure is given as well.

The actual demand equation used in the demand/supply model is constructed by retracing the steps outlined in equations 2-5 and 2-8. Multiplying the end-use factor equation* 2-4 by the DRI forecast of the demand indicator, and adding the forecasted values of inventory change and exports, less imports, yields an equation relating U.S. production to the price and other variables in equation 2-8.

Results of Estimation. The full results of the estimated end-use factor equations are given in Appendix 2-B. A useful way to summarize the results is to use the concept of elasticity of demand. Price elasticity of demand is defined as the percent change in quantity demanded resulting from a given percent change in price, all other factors held constant. It gives a convenient summary of the relationships specified by a given demand equation. The formula for elasticity is:

$$\varepsilon = \frac{\frac{\Delta Q}{Q}}{\frac{\Delta P}{P}}$$

where Q is quantity demanded and P is price. A high value of $\varepsilon$ (greater than one) means that demand is relatively price-sensitive, whereas a low value of $\varepsilon$ implies the opposite. Products with low demand elasticities are in a better position to pass through to the customer the added costs of pollution control. The own price elasticity shows the effect of a product's own price on its demand, and the cross-price elasticity shows the effect of the price of substitute goods on its demand.

Table 2-2 lists the pulp and paper industry sectors, their own-price elasticities, their substitutes, and their cross-price elasticities. In most cases, confidence intervals for these estimates are small. The table shows that the own-price elasticity estimates of most of the product sectors are relatively inelastic. Exceptions are Bleached and Unbleached Kraft Papers, Glassine and Greaseproof Papers, Cotton Fibre Papers, Uncoated Groundwood Papers, Thin Papers, and Solid Bleached Board; all with elasticities greater than one. Some product sectors are extremely inelastic. These include Tissue paper, Uncoated Freesheet, and Solid Bleached Bristols.

Several product sectors have high cross-price elasticities, implying that price rises due to pollution costs could significantly affect demand if they are not matched in the competing sectors. Glassine and

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*All variables except the own price PQ and EUF in the end-use factor equation are also assumed exogenous in the demand/supply model. As with other variables, these are taken from DRI forecasts. These forecasts are described below.

## TABLE 2-2. SUMMARY OF DEMAND ELASTICITIES

| Price | Own Price Elasticity* | Substitute | Cross-Price Elasticity of Substitute |
|---|---|---|---|
| Unbleached Kraft | 1.49 | Plastic Film | .17 |
| Bleached Kraft | 3.86 | Plastic Film | .67 |
| Glassine | 2.14 | Plastic Film | 1.16 |
| Spec. Industrial | .73 | n.a. | n.a. |
| Newsprint | .63 | Uncoated Groundwood | .35 |
| Coated Printing | .64 | Uncoated Groundwood | .23 |
| Uncoated Freesheet | .38 | Uncoated Groundwood | .22 |
| Uncoated Groundwood | 2.65 | Newsprint, Uncoated Book Papers | 2.65 |
| Thin Papers | 1.07 | Chemical Woodpulp Papers | .82 |
| Solid Bl. Bristols | .41 | n.a. | n.a. |
| Cotton Fiber | 2.06 | Chemical Woodpulp | 1.12 |
| Tissue | .06 | n.a. | n.a. |
| Board | | | |
| Unbl. Kraft Liner. | .61 | Plastic Films, Polystyrene, Hard Plastic Packaging | .42 |
| Bl. Kraft Liner. | .61 | ** | .42 |
| Bl. Kraft Folding | .73 | Plastic Pouches, Film & Hard Packaging | .48 |
| Semi-Chem Corr. | .61 | ** | .42 |
| Recycled Liner. | .61 | ** | .42 |
| Recycled Corr. | .61 | ** | .42 |
| Recycled Folding | .73 | Plastic Pouches, Film & Hard Packaging | .48 |
| Constr. Paper & Bd. | .68 | Solid Wood Products | n.a. |
| Molded Pulp | n.a. | n.a. | n.a. |
| Solid Bl. Board | 1.15 | Plastic Film | .39 |
| All Other Board | .65 | Plastic Pouches, Film & Hard Packaging | .07 |
| Pulp | | | |
| Dissolving | .59 | n.a. | n.a. |
| Market | n.a. | n.a. | n.a. |
| Total | | | |

Source: DRI demand equations
*Absolute Value
**Same as for unbl. kraft liner
n.a.: data not available for emprirical estimate of elasticity

Greaseproof papers, Cotton Fibre papers, and Uncoated Groundwood papers all have cross-price elasticities greater than unity. The cross-price elasticity for Bleached Kraft Papers is also relatively high. Products which have very low cross-price elasticities include Unbleached Kraft Papers and Uncoated Freesheet. For some product sectors such as Tissue and Solid Bleached Bristols, data are not available to estimate cross-price elasticities.

The Macroeconomic Forecast. Values of the exogenous variables in the demand models, such as demand indicators, are taken from the March 1980 "trend" forecast of the U.S. economy, made by DRI's macroeconomic model for the period 1980-85. This forecast shows a recession with declines in real GNP through the last three quarters of 1980 followed by gradual recovery in 1981. Inflation is expected to abate gradually after the credit squeeze in the first half of 1980, although the "core" rate of inflation due to wage increases could remain at around ten percent through the early 1980's. In the following years, 1982-85, a predicted move toward a balanced budget is expected to reduce the share of consumer spending in GNP, while tax cuts and increased defense expenditures are predicted to boost investment spending. This shift from consumption to investment spending has implications for the relative recovery rates of different paper and board grades. It is expected that paper grades associated with advertising (Newsprint, Coated Printing Papers) and fiber boxes and other packing materials used for consumer goods will fare less well. Table 2-3 shows the movements of some important variables in the forecast.

## Solution of the Model

The supply and demand curves for each sector are combined to form a product sector model with can be solved to predict the equilibrium path of the market over time.* As described earlier, the demand relationship described in equations 2-5 and 2-8 relates price to U.S. production. The supply curve developed relates U.S. production to the marginal cost (dollar per ton) of that output. Adding the assumption of competitive behavior,

$$\text{Price} = \text{Marginal Cost} \qquad (2\text{-}9)$$

closes the system. This is the basic structure of the demand/supply models used to forecast price and output in each product sector.

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*The procedure for the five linerboard and corrugating medium sectors is somewhat more complex. The supply and demand of all five sectors is modeled jointly to capture substitute and complementary relationships. See discussion in Appendix 2-B.

TABLE 2-3. AVERAGE ANNUAL PERCENT CHANGE OF ECONOMIC VARIABLES IN DRI CONTROL FORECAST

| | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 |
|---|---|---|---|---|---|---|---|
| Real GNP | 2.3 | 0.2 | 1.5 | 4.3 | 3.4 | 2.6 | 3.8 |
| Consumer Price Index | 11.4 | 12.9 | 10.2 | 9.6 | 8.8 | 8.0 | 8.1 |
| Consumer Expenditures except Services | 1.3 | 0.1 | 0.6 | 3.4 | 3.4 | 2.7 | 3.5 |
| Printing, Index | 4.1 | -1.6 | 0.3 | 6.2 | 3.9 | 3.0 | 4.5 |
| Wholesale Prices (Costs) | | | | | | | |
| Energy | 26.6 | 48.7 | 27.5 | 19.1 | 12.2 | 10.5 | 12.4 |
| Chemicals | 11.8 | 19.0 | 12.2 | 9.6 | 7.6 | 6.0 | 6.7 |

Source: DRI Pulp and Paper Review (March 1980), p. 15.

The demand side of the model is driven by values of the exogenous variables from the DRI model and lagged prices. On the supply side, total capacity is given exogenously. For each year, the model is solved for the market-clearing price and quantity. A base case is established for 1979 to 1985. This not only creates a reference case, but also establishes a series of lagged prices to start the analysis of the effects of treatment costs. Starting with 1983, supply curves embodying costs from each treatment option are used to calculate an equilibrium price and quantity for each year and option. Although mills are not required to begin treatment until 1984, they are assumed to incur costs beginning in 1983. The model also calculates total industry contribution to capital (revenues less variable costs). Projections for each treatment option are made through 1985.

Certain industry level impacts -- effects on prices, output, capacity utilization, and contribution -- can be estimated directly by comparing the base case with the various pollution control cases. To look at questions of capital availability, capacity expansion, employment, and mill closures further analysis is required. These methodologies are discussed below.

## Capital Availability Analysis

The capital availability analysis examines the ability of the industry to finance investments in new capacity, both without and with pollution controls. The results of the analysis also provide a check on the capacity expansion forecasts used in the demand/supply analysis. Two different approaches are used in the analysis. The first implictly assumes that if investments are profitable, given current costs of capital, the capital market will provide the money for those investments. This approach focuses on the profitability of investments in new capacity in each of the product sectors. The second approach focuses on the ability of the industry to finance capacity expansion from its current cash flow without relying on outside sources of capital. This corresponds to a worst-case "capital-squeeze" situation.

### Profitability of New Capacity

To determine whether a certain investment in capacity expansion is profitable, it is not enough to compare price and unit total costs in a single year. The discounted cash flow over the life of the investment must be taken into account. Since new investments are made each year, it is necessary to repeat the analysis for each year in order to evaluate the feasibility of financing the entire capacity expansion forecast for a particular product sector. This section explains in greater detail the assumptions and methodology used to evaluate the profitability (and hence feasibility) of the capacity expansion forecasts used in the demand/supply models.

Let:

$P_i$ = price in ith year (from demand/supply analysis) (current dollars)
$C$ = unit variable costs (current dollars)
$K$ = unit capital costs
$CRF$ = capital recovery factor
$K_f$ = discount factor for firm (assumed constant for all firms and periods)
$N$ = lifetime of investment

(Prices and variable costs are escalated with the rate of inflation, while capital recovery is fixed in nominal terms. The nominal discount rate is used.) The present value of an investment of one unit of capacity in year t is:

$$PV_t = \sum_{i=t+1}^{t+n} \frac{P_i - C - CRF \times K}{(1+K_f)^i} \tag{2-10}$$

The investment is profitable if $PV \geq 0$.

Unit capital costs are based on the average costs per ton of positive capacity expansions for each product sector reported in the 308 Survey. In some cases adjustments were made to the survey results if they seemed unreasonable, i.e., if they were grossly inconsistent with expansion costs for roughly similar product types. For example, reported per ton expansion costs for Uncoated Groundwood were far higher than for Newsprint and Uncoated Freesheet. Therefore they were adjusted downward.

The present value is calculated for a unit of investment in each year of the forecast period. For prices after the last year considered in the analysis (1985) they are assumed to grow at a real rate of 0.5 percent per year from the 1985 price.* Each capacity expansion forecast can be evaluated on the basis of the margin of profitability and on the trend of profitability over the forecast period. Of course, the profitability of investments in later years depends on the capacity forecasts made in previous years, but it was not feasible to consider alternative forecasts of capacity expansion.

### Cash Flow Available for New Investment

The second approach examines the ability of the industry to finance new investments out of current cash flow. Costs of capital expansion are obtained by multiplying the amount of new capacity in a given year and product sector by the unit capital cost for that sector obtained from the 308 survey. Cash flow available in a given year is defined as

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*Personal communication, R. Young, DRI.

$$CASH = (1-t) \times (R-C-V-B) \qquad (2-11)$$

where:

$t$ = corporate income tax rate
$R$ = total revenue
$C$ = variable costs
$V$ = reinvestment (assumed equal to depreciation)
$B$ = interest payments

It is difficult to obtain estimates of total reinvestment and interest payments for a given product sector. The method used here is to take the 1978 values of these variables for all mills from the 308 Survey, and then to add the imputed amounts for new capacity based on the estimates of new capacity costs and the cost of capital used in this study.

The cash flow analysis described above concentrates on the amount of funds in each product sector available to finance investments in pollution control. Examining such broad aggregates may overlook potential problems that individual mills within a product sector may face in meeting the required investments in pollution control. Therefore a cash flow analysis similar to the product sector-wide analysis was made for each mill, comparing its cash flow and required investment cost. This approach is conservative because multi-mill firms may be able to shift investment funds from one mill to another. On the other hand this may not be so if extra funds are absorbed by competing demands.

The measure of cash flow used is the same as in equation 2-11 except that whether or not to apply the tax rate depends on the profitability of the individual mill. If it is not profitable, the formula is

$$CASH = R-C-V-B \qquad (2-12)$$

This amount is compared with the capital cost of the pollution control equipment, I. There is some question whether reinvestment costs, V, should be subtracted from cash flow. If a firm has more than one mill, it might cover these costs out of other revenues. However this cannot be true of all mills. The effect of removing V from equations 2-11 and 2-12 is examined in Section 8.

Although this mill-specific capital availability analysis resembles the shutdown analysis (discussed in the next section) it is not the same. The shutdown analysis examines the present value of the mill to see whether it is economical to stay open. This analysis asks whether the mill could raise the investment cost of pollution control completely from its own cash flow within one year.

## Mill Shutdown Analysis

### Overview

The decision to shut down the operation of a mill is necessarily complex, involving a multitude of criteria, many of them subjective. Not only must the present situation be examined, but also any likely changes in the future. A few of the most important factors to be considered are:

1. Present and expected profitability of the mill;
2. Current market value (salvage value) of the mill, the opportunity cost of keeping the mill open;
3. Required pollution control investment;
4. Expected increase in annual costs due to pollution control requirements;
5. Expected product price, production costs, and profitability of the mill after pollution control equipment is installed and operating;
6. Other major economic developments expected for the mill(i.e., technological obsolescence, change in competitive situation, etc.).

These parameters can only be estimated. Even a mill manager would be uncertain of much of the pertinent information. However, if our estimates are reasonably accurate and our methodology correct we should be able to indentify those mills for which shutdowns are possibe and to eliminate those mills whose position seems secure.

Given estimates of individual mill production costs from the 308 Survey and price and capacity utilization information from the product sector demand/supply analyses, the major steps of the shutdown methodology are:

1. Calculate expected revenues and costs of mill before and after pollution controls;
2. Identify mills which are "base case" shutdown candidates before pollution controls by applying the simplified "shutdown formula" explained below;
3. Identify added mills which are shutdown candidates after pollution controls by applying the shutdown formula.

It should be noted that the methodology developed here is oriented to existing mills, not new mills. Reductions in the profitability of new mills due to pollution control costs are handled in the capital availability analysis.

### Shutdown Formula

When faced with pollution control requirements the mill manager faces the following decision: whether to make an additional investment and incur additional operating costs or to sell the plant.

His alternatives are:

1. Sell the mill -- either as an operating entity or as scrap. This is the salvage value of the plant; call is S; or
2. Make the investment, I, and realize the value of the cash flows expected from remaining open N years with discount rate i.

$$PV = \sum_{n=1}^{N} \frac{CASH_n}{(1+i)^n}$$

Because the mill will remain open many years if the manager invests to meet control standards, the analysis must take into account the cash returns expected over the life of the mill and equipment plus the salvage value of the mill at the end of the last period. The future returns are discounted back to the present year, using an interest rate equal to the firm's after tax cost of capital. The mill will be kept open if the cash returns less investment costs exceed the expected salvage value. If they do not, the owner will sell the mill. Thus, the owner will sell if:

$$S > \sum_{n=1}^{N} \frac{CASH_n}{(1+i)^n} + \frac{S}{(1+i)^N} - I \qquad (2\text{-}13)$$

Cash flow is defined as revenues less operating costs net of taxes less reinvestment plus the subsidy on depreciation due to its being a deductible non-cash cost. In mathematical terms, in the post-control case:

$$CASH = (R_2 - C_1 - C_2) x (1-t) - V_1 - V_2 + t(D_1 + D_2) \qquad (2\text{-}14)$$

where the terms are defined in Table 2-4.* Payments to suppliers of capital are not deducted as costs. Furthermore, the tax subsidy on interest payments is not included because it is already accounted for by use of the after tax discount rate.

Actual cash flow is difficult to estimate because prices, volumes and costs will change every year. It is assumed that output, operating costs and reinvestment remain unchanged in real terms. Furthermore, an "average" real price is calculated which has the same present value as the price series yielded by the demand/supply analysis and extended over the period 1983-97 (representing a 15 year lifetime). Therefore the present value of the stream of constant real flows $(R_2-C_1-C_2)$ x $(1-t) -V_1-V_2$ can be found by multiplying this expression by the capitalization factor $W(N,i)$ where i is the real cost of capital $(K_f)$ corrected for the inflation rate.

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*The pre-control case, base closure, is similar except that $R_1$ is used, and $C_2 = V_2 = D_2 = 0$.

## TABLE 2-4. DEFINITIONS OF TERMS

$R_1$ = revenues before pollution controls
$R_2$ = revenues after pollution controls
$I$ = investment required for pollution control
$C_1$ = variable costs before pollution controls
$C_2$ = variable costs of pollution controls
$D_1$ = annual depreciation before pollution control*
$D_2$ = annual depreciation on pollution control equipment
$B_1$ = interest payments on plant
$B_2$ = interest payments on pollution control equipment
$V_1$ = annual reinvestment before controls
$V_2$ = annual reinvestment for pollution equipment
$S$ = estimated salvage value of existing plant
$N$ = life in years of pollution control equipment
$i$ = real required after-tax rate of return on investment
$K_f$ = nominal after-tax rate of return on investment (cost of capital)
$t$ = corporate income tax rate
$W(N,i)$ = present value of an annuity for N years at i percent

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*Assumed to include all non-cash "costs", e.g. forest depreciation allowances.

The subsidy on depreciation must be treated differently because depreciation payments remain constant in nominal rather than real terms. Assuming straightline depreciation, the present value of the depreciation subsidy is $t(D_1+D_2)\ W(N,K_f)$ where W is defined in terms of the nominal rather than the real discount rate.

This yields a simplified version of the above shutdown inequality, i.e., the mill is shut down if:

$$>\{(R_2-C_1-C_2)(1-t)-V_1-V_2\}xW(N,i) +t(D_1+D_2)\ W(N,K_f)$$

$$+\frac{S}{(1+i)^N} -I \qquad (2\text{-}15)$$

where S, R, C, V and D are all defined in real terms. The sources of information and assumptions made for the variables are discussed in a following section.

## Some Refinements

The above is the basic equation used in the shutdown analysis. A few refinements are necessary, however, to take into account certain important special factors.

### Investment Tax Credit

To encourage new investment in plant and equipment, the U.S. government now allows a corporation an income tax credit equivalent to 10 percent of the invested capital.* This, in effect, reduces the required pollution control investment costs by 10 percent, assuming the company is profitable. In the equation above, I is replaced by 0.91.

The federal income tax code allows companies installing qualified pollution control equipment on plants built before 1976 to take the first 15 years of depreciation in 5 years. However, if they do this they do not get the 10 percent investment tax credit. Since the tradeoff is about even, most companies forego the complexities of rapid depreciation for the immediacy and simplicity of the investment tax credit. For this reason, the rapid depreciation allowance is ignored in our analysis.

Unprofitable Plants. If in the initial calculation it becomes apparent that the mill will be operating at a loss, then the income tax rate is zero. However, if depreciation and interest payments are large, there still might be a positive cash flow from the project. Therefore, the mill may stay open if the present value of this cash flow exceeds the salvage value. In this case taxes play no role at all. Our cash flow equation is then just:

$$\text{CASH} = R_2-C_1-C_2-V_1-V_2 \qquad (2\text{-}16)$$

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*This is for equipments lasting more than seven years. For shorter-lived equipment, the credit is reduced.

Also, in this case the full dollar amount of I, the pollution control investment is used since the 10 percent investment tax credit is of no use.

Another possibility for multi-mill firms is that even though a single mill is unprofitable, the firm as a whole may be profitable, or vice versa. However, it is not possible to identify specific firms from the information in the 308 Survey because of confidentiality restrictions. Therefore the formula for profitable or unprofitable mills is used depending on the financial condition of the individual mill.

### Summary of Algorithm

Table 2-5 presents the algorithm which is the basis for the shutdown analysis. It describes the situation after pollution controls are imposed. The base case shutdown analysis is similar, except revenues are calculated from base case prices ($R_1$ instead of $R_2$), and all pollution control costs ($C_2$,$B_2$,$D_2$,I,$V_2$) are zero.

### Application of Shutdown Methodology to 308 Survey Data

The previous discussion described a general methodology which could be applied to any data set. This section describes some problems encountered in applying this methodology to the 308 Survey financial data and the modifications that were made to the methodology to meet those problems. These problems include variations in prices for a given product sector received by individual mills; the question of whether to treat transfer and non-tranfer (i.e. integrated and non-integrated) mills differently; and the question of how to define base case closures.

Data for the shutdown analysis are taken from three main sources: the 308 Survey of individual mills; the technical contractor's report; and the results of the product sector demand/supply analyses. The 308 Survey supplies information for production costs (including interest and depreciation), output levels, and salvage value (working capital plus a fraction of undepreciated capital). Information on capital and operating costs and equipment lifetimes of pollution control equipment comes from the technical contractor. The demand/supply analyses provide price data used to calculate mill revenues.

One major problem is that the demand/supply analyses yield only a single price for each product sector. Such a price is not suitable for cash flow calculations for individual mills because of significant variations in product grade and quality within a single general product sector. Using a single price would over-estimate the revenues of mills with relatively low-grade products and underestimate revenues for high-grade products. A check of 308 Survey data showed that survey revenues are much more highly correlated with survey production costs than are calculated with survey production costs than are calculated revenues based on a single price. This suggests that higher cost products tend to command higher prices, and hence that using a single price will bias the results of the cash flow analysis.

## TABLE 2-5. SHUTDOWN ALGORITHM

Check for profitability

(1) is $R_2 > C_1 + C_2 + D_1 + D_2 + B_1 + B_2$

if yes (2)
if no (3)

Decision model for profitable plant

(2) is $S \geq \{ (R_2 - C_1 - C_2)\ (1-t) - V_1 - V_2 \}\ W(N,i)$

$$+t(D_1 + D_2)W(N,K_f) + \frac{S}{(1+i)^N} - .9I$$

if yes (4)
if no (5)

Decision model for unprofitable plant

(3) is $S \geq (R_2 - C_1 - C_2 - V_1 - V_2)W(N,i) + \frac{S}{(1 + i)^N} - I$

if yes (4)
if no (5)

Outcome

(4) Shut-down mill
(5) Mill remains open

To take this into account, a specific revenue adjustment factor ("$\alpha$") was computed for each mill. This factor is the ratio of each mill's estimated revenue using single 1978 prices to actual revenues reported in the 308 Survey. This ratio is assumed to be constant through the period 1983-85. In other words, predicted mill revenues in 1983-85 are obtained by multiplying estimated revenues based on predicted 1983-85 product sector prices by the factor $\alpha$. This is not simply equivalent to using survey revenues in the shutdown analysis, because product sector prices change both between 1978 and the 1983-85 base case and between the base case and the treatment options. (Production costs (exclusive of pollution control) are not assumed to change over the period.) Nor does this method imply a constant markup of price over cost across mills, rather it merely takes the particular mill's 1978 price-costs margin as a base for the forecast.

This method depends on the assumption that survey revenues reflect the market value of the mill's output. However, many mills (nearly one-half the total) transfer at least some of their output to other mills owned by the same firm rather than selling it on the open market. To the extent that the transferred output is valued in the survey by some method other than market price, the survey revenue will understate the market value of the mill's output. Therefore, survey revenues may not be a valid basis to adjust revenues as described above to account for product grade differences. This abstracts from any additional economies that the firm may obtain from the integrated operation of several mills.

As a test, closure analyses were performed for the subset of mills which transferred no output or which stated in the 308 Survey that they valued transferred output at market prices. There was no significant difference in closure rates for this subset than for the set of all mills in the sample. Therefore, the shutdown results are given for all mills in the sample only.

Even when transfer mills which do not value output at market prices are eliminated, over 20 mills report revenues less than "cost of goods sold" (i.e., operation and maintenance costs) plus "general sales and administrative costs," while 14 mills report revenues less than "cost of goods sold" alone; yet only three report an intention to curtail operations or shut down. This is hard to reconcile with economic theory, including the shutdown methodology described above. Given the current reasonably healthy forecasts for the industry, our methodology could overestimate the number of plant closures.

The approach adopted here is to treat transfer and non-transfer mills differently. For non-transfer mills the shutdown formula was applied without further change. It was believed that although some mills might stay open in the short run even though they appeared to be closure candidates, it was not likely that they could stay open under such conditions for a long period if they were not integrated operations and hence had to sell their output on the open market. This assumption of course runs the risk of ignoring other unknown factors that might allow that mill to stay open. Such factors might include the opportunity cost of employed labor or the flexibility of operating with a larger number of mills. On the other hand, transfer mills might be able to stay open indefinitely even though they appear to be closures if their revenues were underestimated. Therefore, in the analysis a transfer mill is never shut down as long as it has at least as high a predicted cash flow in 1983-85 as it reported in the 308 Survey.

The effects of other shutdown rules on the results of the analysis are examined in Section 8. These include applying the rule about 1983-85 cash flow relative to Survey cash flow either to all mills or to no mills. Such alternatives tend to have significant effects on the number of predicted base case closures but not on the closures due to treatment costs.

Lastly, 20 mills in the 308 survey were excluded from the shutdown analysis because they had more than 20 percent of production in product sectors for which no demand/supply analysis results were available, i.e. All Other Paper and Molded Pulp. However, the likelihood of any of these mills closing is examined in the sensitivity analysis in Section 8. Closure estimates are bracketed by considering price increases which reflect either full- or no-cost passthrough. Although no demand/supply analysis was done for Market Pulp either, too many mills produce Market Pulp to allow them to be excluded from the analysis. Therefore base case 1983-85 price forecasts were obtained for each pulp grade. However, no price increases due to pollution costs were forecast for pulp. (The implicatons of this are discussed in Section 8.)

### Data Used in Shutdown Analysis

This section describes the sources of information and assumptions used to derive the value of each variable in the shutdown formula.

$R_1$ and $R_2$ Revenues. Revenue is the product of a mill's reported production and the price of that product, summed over all products that the mill produces. As described above, this sum is then multiplied by the mill-specific revenue adjustment factor, $\alpha$, before being used in the shutdown formula.

$\alpha$, Mill-Specific Revenue Adjustment Factor. $\alpha$ is the ratio of revenues reported in the 308 Survey to revenues calculated using a mill's reported output and 1978 product sector prices.

I, Investment Required for Pollution Control. This is taken from the estimates provided by the technical contractor, either for individual mills or for subcategories.

$C_1$, Variable Production Costs. These are annual operating costs taken from the 308 Survey and adjusted to 1978 price levels. They are not adjusted for changes in real costs between 1978 and 1983-85. Although this will underestimate costs in 1983-85 somewhat, it was believed that simply indexing costs by their expected real price increases would overstate costs significantly because it would not take into account changes in production practices in response to these cost increases. For example, energy cost increases have led to increased use of wood chips and other waste as fuel. This issue is discussed further in Section 8.

$C_2$, Variable Costs of Pollution Controls. These are taken from the estimates provided by the Technical Contractor. They are not adjusted for real cost increases between 1978 and 1983-85.

$D_1$, Annual Depreciation before Pollution Control. $D_1$ is reported depreciation in the 308 Survey.

$D_2$, Depreciation of Pollution Control Equipment. In estimating the annual depreciation of the pollution control equipment to be used for tax purposes, we use a straightline figure based upon N, the expected useful life of the equipment, i.e., $D_2 = I/N$. This has the advantages not only of being simple, but also of erring on the low side, since the straight-line method is the most conservative. If firms use sum-of-the-year's-digits or other accelerated depreciation methods, fewer mills will close than our analysis will predict.

$B_1$, Interest Payments on Plant. $B_1$ is taken from reported interest payments in the 308 Survey.

$B_2$, Interest Payments on Pollution Control Equipment. $B_2$ is the investment cost, I, multiplied by the interest rate on industrial revenue bonds.

$V_1$ and $V_2$, Reinvestment. It is assumed that annual reinvestment costs equal depreciation ($D_1$ or $D_2$) adjusted for inflation. Straightline depreciation implies a constant nominal amount of depreciation, whereas actual reinvestment costs, once they begin, can be expected to stay constant in real terms. This is reflected in the shutdown forumula by using different capitalization factors for these two items. Furthermore, it is assumed that relatively new plants will not begin to incur reinvestment costs for another five years.

S, Salvage Value. One of the biggest unknowns in this analysis is what the managers perceive as the salvage value of their mills, the opportunity cost of keeping their mills open rather than selling them. Obviously, there are no available statistics on such figures, except in those few cases reported in trade journals where mills might have been salvaged and their expected returns stated. The only generally available statistics are the book values of the mills, or the expected replacement values. We define salvage value as:

$$S = M + \beta\ (K-L)$$

where:

$M$ = working capital
$K$ = original cost of mill
$L$ = cumulative depreciation on mill
$\beta$ = fraction of book value considered salvageable

Information on M, K and L comes from the 308 Survey. Pollution control equipment is not assumed to have any terminal salvage value.

The fraction $\beta$ represents a small percentage of replacement value, and, depending upon the age of the mill, of book value as well. This is because we are most concerned about those situations in which the mill is actually "shut down," that is, abandoned and sold for scrap. In some situations, a mill might be worth much more if it could be converted to another process or product. However, in these cases the mill is not "shut down," rather, its ownership is simply transferred. The employment and social impacts of such a transfer are probably not significant. However, in cases where the mill is actually abandoned and sold for scrap, the employment and social impacts will be significant. It is toward these situations that the analysis is directed. In the analysis a value of $\beta$=.125 is used to represent a small fraction of book value as salvageable. The sensitivity of the results to other values of $\beta$ is examined in Section 8. Although there is some effect on the number of base closures, there is little effect on the number of closures due to treatment costs.

N, Life of the Pollution Control Equipment. One of the most crucial variables in our analysis is N, the number of years over which pollution control investment is amortized. A shorter lifetime results in fewer years of income and a greater likelihood of closure. In general, N should closely reflect the useful life of the pollution control equipment. However, lifetimes vary substantially. Ponds and concrete tanks, for example, might be expected to last indefinitely. On the other hand, motors and pumps might last only 5-10 years. Finally, in many situations the useful life of the plant itself might be only 10-15 years, because of the plants current age and/or the rate of technological obsolescence in the industry. We use 15 years as an average in the analysis.

$K_f$, Nominal Rate of Return. Theoretically, a firm will invest in any project with an expected net return at least equal to its cost of capital. Many industry reports claim, however, that they do not invest in projects unless the expected after-tax return is 20 percent or even higher. This is because managers in those industries perceive their investments as being very risky. They are thus adding a risk premium to their cost of capital in arriving at their minimum rate of return. However, pollution control investments are almost risk-free investments, since they are designed simply to preserve the return on capital already existing. Therefore, the expected return is virtually certain, although the price increase which may result will be unknown. For these reasons, we use a nominal rate of return, $K_f$, for pollution control investments equal to the industry's cost of capital, i.e., 12.8 percent.

*i, Real Required Rate of Return*. When discounting constant, real cash flows, the nominal rate of return is adjusted for inflation. The relationship between the real and nominal discount rates and the rate of inflation ($\theta$) is:

$$i = \frac{K_f-\theta}{1+\theta}$$

The DRI forecast yields an average rate of inflation through 1990 of 7.5 percent. Therefore, given the nominal rate of return ($K_f$=12.8 percent), this yields a real rate of return of 4.9 percent.

*t, Income Tax Rate*. An average tax rate of 50 percent covering both federal and state income taxes is assumed. See the discussion in the part on the capital recovery factor.

*W(N,i), Present Value of an Annuity*. The formula for the present value of a constant cash flow of one dollar per year for N years with a discount rate i is:

$$W(N,i) = \{1-(1+i)^{-N}\}/i \qquad (2-7)$$

Note that if a constant *real* cash flow is assumed, i must be a *real* discount rate as well.

## Indirect Effects on Employment and Earnings

Direct impacts from pollution control regulations such as mill closures or output reductions can be expected to have indirect effects, or output reductions can be expected to have indirect effects, arising both from the reduction in demand for inputs by the affected mill, and reductions in consumption because of both direct and indirect losses in earnings. Input/output analysis provides a straightforward framework for accounting for these indirect effects as long as the direct effects are small and a number of other important limitations are recognized.*

Given a change in final demand in a certain industry, an input/output table can be used to determine the changes in demand (gross output) in other industries that would arise from this change. (The I/O model structure assumes complete and instantaneous adjustment to such a change.) Incorporating households as another sector in the model allows the total effect of changes in household consumption due to changes in income to be included as well. The number obtained from this is the "gross output multiplier."

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*See U.S. Water Resources Council, *Guideline* 5: *Regional Multipliers* (Industry Specific Gross Output Multipliers for BEA Economic Areas) prepared by Regional Economic Analysis Division, Bureau of Economic Analysis, U.S. Department of Commerce, Washington, D.C., January 1977.

However, the change in gross output is not a useful measure of impact because intermediate goods are counted at each stage of production, resulting in substantial double-counting. Only the change in value-added should be counted. The measure of net impact used by the Bureau of Economic Analysis (BEA) (and that adopted here) is earnings, defined as the sum of wage and salary income, other labor income, and payments to proprietors. It does not include returns to capital.* The impact on earnings can be calculated by multiplying the demand change in each sector by the ratio of earnings to gross output in that sector and then summing earnings changes over sectors.

This procedure has been used by BEA to calculate a ratio of change in total earnings to changes in final demand for the "paper and related products" industry, i.e.,

$$\frac{\Delta \text{ Total Earnings}}{\Delta \text{ Total Demand}} = .88 \qquad (2\text{-}8)$$

This number includes direct earnings changes. It must be taken with some caution, because it represents a national average. However, it was not feasible to use state-specific gross output multipliers to obtain similar earnings/final demand ratios for each state. First, doing so would underestimate impacts, since state multipliers only capture indirect impacts in that state. Therefore, summing over state impacts would not yield the national impact because out-of-state impacts would not be captured. Second, the only existing complete set of state multipliers is very outdated. More recent work on a few states indicates that those multipliers are off by as much as 30 percent.**

The total impact of a mill closure or other change in output is just:

$$\Delta\text{Total Earnings} = .88 \times \Delta\text{Revenues}$$
$$\text{where: } \Delta\text{Revenues} = \Delta\text{Sales}$$

The direct impact on earnings at a mill can be estimated from 308 Survey information. The indirect impact is the difference between total and direct earnings. This approach takes into account the differences in degree of integration among mills. For example, closure of a non-integrated mill with relatively low value-added would be expected to have a greater effect on indirect earnings than an integrated mill with the same final output.

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*This is a more reasonable assumption for regional impact analysis since owners of capital are likely to be outside the region. Use of this measure would underestimate impacts at the national level. The extent of this error is unclear since it depends on the effect of changes in wealth on consumption. These effects are likely to be less than those of earnings on consumption.

**Private communication, Joseph Cartwright, BEA

Employment impacts can be calculated from the 308 Survey for the direct impacts and from regional employment/earnings ratios for the indirect impacts. It is assumed that all of the indirect impact of a mill closure occurs in the geographical region where the mill is located. Also the indirect impact is assumed to be evenly spread over the region in proportion to the distribution of employment in the region.
Therefore:

$$\Delta\text{Indirect Employment} = \Delta\text{Indirect Earnings} \times \text{Employment/Earnings}_i \qquad (2\text{-}20)$$

where Employment/Earnings$_i$ is the average of this ratio for individual states in region i weighted by their share of employment in the region. This allows us to use available state employment/earnings information.*

This approach does have a number of limitations. Firstly, losses in output due to plant closures are not necessarily equal to changes in final demand because other mills may increase their output somewhat because of increased prices. Output in other sectors may also expand because of substitution. On the other hand, impacts are underestimated because only actual closures, and not simple reductions in output, are covered by the analysis. Secondly, the use of a single national earnings/final demand ratio ignores regional differences in costs and input mixes. Finally, the effects of changes in wealth on consumption have been ignored, thereby underestimating impacts somewhat.

## Balance of Trade Impacts

As the world's largest producer of forest products, the United States supplied roughly 35 percent of total world pulp, paper and paperboard in 1978. However, we are also the world's largest consumer of these products. This results in the United States being a net importer of both pulp, paper and paperboard. While nearly six percent of total U.S. pulp, paper and paperboard production was exported in 1978, imports equalled about 14 percent of production. Our major imports are Newsprint and Bleached Kraft Pulp. Interestingly, we are also major exporters of Bleached Kraft Pulp, in addition to Kraft Linerboard and Dissolving Pulp.

In analyzing the impact of pollution control regulations, several factors which affect our competitive position must be considered. The first is the change in prices which results from the imposition of regulations. The demand/supply analysis provides prices with and without controls, so that the relative price increase can be determined.

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*See U.S. Water Resources Council, 1972 OBERS Projections: Regional Activity in the U.S., Washington, D.C. 1972.

Several of our major competitors, particularly Canada and the Scandinavian countries have also instituted pollution control regulations, with resultant impacts on their prices. The impact of regulations on foreign producers cannot be measured with any certainty, especially since some governments have major subsidy programs to underwrite part of the costs of expansion and pollution control equipment. A good example of this is the programs of the Canadian national and provincial governments to increase employment.

A further set of factors affecting the competitive position of American producers are trade agreements, tariffs and exchange rates. In general, world trade is expected to expand as barriers to trade are reduced. However, after 1984 Scandinavia will be able to export to the Common Market duty free, while the U.S. and Canada will be charged tariffs.

Several developing countries and Japan are expanding their domestic capacity. This may lead to a change in the mix of products the U.S. exports.

Future production and consumption levels are projected by the DRI international pulp and paper models, in conjunction with their models of the economies of various countries. For certain product sectors, predictions of exports and imports are also available from DRI. These do not explicitly take account of future cost increases due to pollution control requirements, but they do indicate the types of changes which can be expected in these sectors.

## Limitations of the Analysis

Most of the important assumptions and limitations of the analysis have been identified above in the process of explaining the major features of the assessment methodology. Nonetheless, some warrant emphasis, particularly the assumptions which underlie the developemnt of the supply curves, the forecasting of capacity expansion, the demand curves and the shutdown methodology.

With regard to supply we have assumed that all product prices are based on variable costs and, moreover, that average variable costs are suitable surrogates for marginal variable costs in the construction of product sector supply curves. Also, only a single price is estimated for each product sector. Furthermore, we assume that the cost and production data collected in 1978 can be properly used to construct supply curves through 1985, and that BCPCT and BATEA costs must be taken into account starting in 1983 and that they remain constant thereafter.

Some simplifying assumptions had to be made to convert the quarterly demand curves to an annual basis, i.e., using annual average prices and demand indicators rather than quarterly values. Another limitation of our approach is the treatment of exports, imports, and inventory change as exogenous to the supply-demand analysis. The underlying macroeconomic forecast is also subject to error.

Capacity expansion forecasts, based on API and DRI estimates, are exogenous to the demand/supply models. To include new capacity as it may come on stream we assume that is is low variable cost (or at most lower than marginal high-cost) capacity. Finally, to estimate whether or not resources are available to finance the new capacity we assume that all mills or firms are subject to conditions that would result in the use of the same capital recovery factor.

The results of the shutdown methodology can be considered only a rough estimate due to data limitations and the complexity of the actual decision. A number of secondary factors, such as benefits of integrated operations and the costs associated with reducing the workforce through firing or early retirement, could not be included. Another limitation is the use of 1978 data to forecast production and costs. Some data, such as the cost of capital, are not available for individual firms, while others, such as salvage value, are difficult to define or estimate.

The measurement of indirect impacts is limited by the lack of earnings/final demand ratios which account for regional differences in costs and input mixes. Also, indirect impacts may be overestimated because closures are considered reductions in output, while production may be shifted to another location. On the other hand, impacts may be underestimated, due to ignoring the effects of changes in wealth, and changes in output other than closures.

A thorough analysis of the balance of trade impacts would require the collection of data and a development of an international trade model beyond the scope of this study. However, the general impact of price changes is presented.

The implications of these assumptions and limitations, as well as the effects of alternative assumptions on the analysis, are discussed in detail in Section 8.

# Appendix 2-A

## The 308 Survey

The economic analysis of various pollution control options is based in large part on information collected through a questionnaire issued by EPA under authority of section 308 of the Clean Water Act (the 308 Survey). This questionnaire was sent to approximately 700 mills in the pulp, paper and paperboard industry. A total of 633 responses to the 308 questionnaire, representing 648 mills, were included in the analysis. A follow-up on the non-responding mills showed that in most cases these mills were closed at the time of the survey, or were not producers of pulp, paper or paperboard.

### Purpose of the Survey

The survey was designed to provide information on mill characteristics, production costs, investment in new capital, and market structure. Of primary concern was information on production costs. At the time of the survey there was only one public source which contained consistent and detailed manufacturing cost information organized in a way directly useful to an impact study.* These costs were for representative new facilities typical of good technical practice in 1974, however, and a host of assumptions would have to be made to translate them into a form which would allow us to construct marginal cost curves for industry product sectors. To develop new manufacturing cost functions and to verify or modify the assumptions made to translate the cost functions into cost curves for the sectors, information for individual mills was needed on the relationship between costs and capacity, capacity utilization, production processes and products, and age of capital.

To determine impacts it is essential to consider questions of demand. The DRI Forest Products model provided the capability to estimate demand on a product-by-product basis. However, we wanted to be able to test the assumptions of this model against information obtained from individual firms concerning the markets for their products. In addition, the demand analysis projects capacity expansion on the basis of announced plans for expansion and specified investment behavior. To assess the forecasts we needed information on individual mills' plans for expansion.

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*Economic Impacts of Pulp and Paper Industry Compliance with Environmental Regulations, Report for Office of Planning and Evaluation, U.S. Environmental Protection Agency, Arthur D. Little, Inc., May 1977.

## Questionnaire

The questionnaire contained 24 questions, and was organized into five parts:

- Identification: Name and address of mill and (if different) name and address of parent company; name, address and telephone of individual responsible for completing the questionnaire.
- Capacity: Mill capacity in various grades of pulp, paper, and/or paperboard.
- Economic Information: Assets and capital investment, revenue, expenses, quantities sold and transferred, and annual production and inventory change information for two fiscal years.
- Annual Operating Costs and Capital and Operating Costs arising from Federal Regulations: Fiber, chemicals, labor and energy costs in the most recent fiscal year; and estimates of capital and operating costs for air and water pollution control and OSHA compliance.
- Future Plans: Planned capital expenditures on air and water pollution control and capacity expansion by product or process; plans to curtail operations; and if applicable, user charges of POTW's.

## Confidentiality

Two procedures were employed to protect the confidentiality of the data. Those mills which sent their responses directly to EPA were protected by the procedures specified in Article XXI, Parts A to F of contract No. 68-01-4675. These included EPA removing the Identification Section from each questionnaire and assigning a code number with region and subcategory identifiers to each questionnaire before they were forwarded to Meta Systems for processing.

Those mills which did not respond directly to EPA sent their completed questionnaire to a third party (Arthur Andersen & Co.) whom they had hired to hold the data and protect its confidentiality. Both sets of data (mills responding directly to EPA and mills responding to Arthur Andersen & Co.) were stored on Arthur Andersen's computer, and Arthur Andersen personnel monitored the use of the data to prevent the exposure of 308 Survey data on an individual mill.

## Limitations of Survey

As noted above, the response rate to this 308 Survey was excellent, and for the most part the quality of the data appears quite good. However, there are a few problems with the questionnaire and/or the responses. In the case of the question dealing with annual operating costs, it is unclear what the mills included in "other costs." It was assumed that these costs included the operating costs necessitated by current pollution control regulations, although this may not always be the case.

A couple of problems arose with responses by indirect dischargers. Due to the wording of the question, the flow level and user charge information is ambiguous. Also, final determination of whether a mill was an indirect or direct discharger was left to the technical contractor.

In some cases, a mill's reported production and capacity levels were inconsistent. Various stages of the analysis required one or the other level. Since it was not possible to determine which was correct, the production and capacity data were used as they appeared on the mill's response.

# Appendix 2-B

## End-Use Factor Equations

This appendix gives the statistical summaries of the regression estimates of the end-use factor equations for each product sector. These were used to construct the demand equations that were part of the demand/supply analysis. The relationship between the end-use factor equation and the overall demand equation was described in Section 2. In some cases end-use factor equations were estimated for more than one grade within a given product sector. Results for each grade are presented here. A special section is devoted to the modeling of demand for the linerboard and corrugating medium sectors because of the added complexity of modeling these sectors jointly.

### Modeling of Demand for Linerboard and Corrugating Medium

The demand for linerboard and corrugating medium grades is more complicated to model than that of most other grades. This is because demand for the converted product, fiber boxes, depends on the total cost of fiber boxes which is the sum of the costs of the linerboard and corrugating medium which make it up. Therefore demand for these two major grade types must be estimated jointly. This section describes DRI's modeling of fiber box demand and a significant modification of it made by Meta Systems to better model substitution effects among competing grades.

DRI's demand methodology has three steps. First, fiber box shipments (demand) for eleven separate industries are forecast. Each group is composed of several two- and three-digit SIC industries based on similarities in their fiber box usage patterns. Within the model, separate demand indicators and end-use factors are developed for each group in the usual way. Demand is then summed over the industry groups to obtain total fiber box demand.

Total demand for fiber boxes is translated into box plant demand for total linerboard and corrugating medium using conversion factors from millions of square feet to thousands of tons. These factors are exogenous to the model.

Finally, linerboard production is broken down into Bleached, Unbleached, and Recycled Linerboard and corrugating medium into Semi-Chemical and Recycled Corrugating Medium. DRI's methodology for this allocation is based on the assumption that demand for recycled grades is a residual which is filled only after operating rates in the virgin fiber grades approach their maximum. In linerboard, the first step is to forecast capacity utilization for solid (Bleached and Unbleached) linerboard. Bleached Linerboard is assumed to be a constant fraction of total solid linerboard production (which equals solid capacity times solid capacity utilization), and Unbleached Linerboard makes up the difference. The difference between total linerboard production and solid linerboard is allocated to Recycled Linerboard. Demand for Semi-Chemical and Recycled Corrugating Medium is determined in a similar way.

Although this allocation method gives reasonable forecasts, it is less suitable for predicting the changes in demand among different grades resulting from changes in relative costs of those grades. This is because the above allocation method does not take relative costs into account. However, changes in cost due to pollution controls are likely to have a significant effect on substitution demand because, for example, pollution control costs for recycled grades are much lower than those for comparable solid grades.

To model these possibilities of substitution, elasticities of substitution were incorporated into DRI's grade allocation equations. The following example shows how this was done for Bleached Linerboard. In DRI's version, Bleached Linerboard is a constant fraction of Total Solid Linerboard, i.e.

$$\text{Bl. Liner} = \text{Sol. Liner} \times \text{Bl. Ratio} \qquad (2B\text{-}1)$$

In the modified Meta Systems version we have

$$\text{Bl. Liner} = \text{Sol. Liner} \times \text{Bl. Ratio} \times A \qquad (2B\text{-}2)$$

where:

$$A = \left( D1 \times \frac{\text{Bl. Liner Price}}{\text{Unbl. Liner Price}} \right)^{-E1}$$

and

$$D1 = \frac{\text{1979 Unbl. Liner Price}}{\text{1979 Bl. Liner Price}}$$

E1 = elasticity of substitution between Bl. and Unbl. Liner.

In equation (2B-2), for a given level of total solid linerboard, the amount of Bleached Linerboard produced is inversely related to the excess of the Bleached Linerboard price over the Unbleached Linerboard price. The D1 term is a baseline adjustment factor, i.e. the substitution effect occurs only if relative price levels differ from the observed levels in 1979. Similar substitution elasticities are used for Unbleached vs. Recycled Linerboard and Semi-Chemical vs. Recycled Corrugating Medium.

It was not possible to obtain econometric estimates of these elasticities. Therefore the following estimates were made on the basis of discussions with DRI industry analysts:

E1 = .1 (Unbleached vs. Bleached Linerboard)

E2 = 1.0 (Unbleached vs. Recycled Linerboard)

E3 = 1.0 (Semi-Chemical vs. Recycled Corrugating Medium).

The results were not overly sensitive to alternate values for these elasticities. The model was tested with values for each elasticity twenty percent greater or smaller than the base case values. Results for Bleached Kraft Linerboard were quite insensitive, a 20 percent increase in the elasticity E1 did not alter the base price increase of 2.63 percent. Increasing the elasticity for Recycled Linerboard (E2) by twenty percent changed its price increase from .18 percent to .25 percent. Increasing the elasticity for Recycled Foldingboard (E3) by twenty percent changes its price increase from 1.41 to 1.53 percent.

The following sequence summarizes the logical steps of the model. These steps are done iteratively until equilibrium values of price and output for each grade are obtained.

1. Given initial price of fiber boxes, determine demand in each end-use industry.
2. Sum these demands to get total fiber box demand.
3. Use conversion factors to get demand for total linerboard and corrugating medium.
4. Use initial set of grade-specific prices to allocate demand among individual linerboard and corrugating grades.
5. Given the supply curve for each grade, set price of that grade equal to marginal cost of the amount demanded from step (4).
6. Calculate price of fiber boxes based on conversion factors and production-weighted averages of individual grade prices.
7. Repeat step (1), etc. until convergence achieved, i.e. values of all variables change by less than .1 percent from values in previous iteration.

## Format of End-Use Factor Equation Regression Results

This section describes the format of the regression results for the individual end-use factor equations used in the demand/supply analysis which are presented below. All equations were estimated using ordinary least squares. The format is that of the econometric and simulation language EPS. It includes the names of the dependent and independent variables, the period of the data (quarterly or annual), start and end dates of the time series, number of observations, and summary statistics of the regression. The names of the variables are those used in DRI's data banks, and their definitions are given with each regression.

The results show the estimated coefficient, standard deviation and t-statistic for each independent variable, including a constant term ("CONSTANT"). Most price terms and some other independent variables are estimated as polynomial distributed lags (PDL). The name of each variable with such a lag gives the specifications of the lag structure according to the following format:

PDL (seriesname{\scalar1}, scalar2, scalar3, pdlrestriction)
where:

| | |
|---|---|
| seriesname | specifies the series to be analyzed. |
| scalar1 | specifies the number of periods the series is lagged. |
| scalar2 | specifies the degree of the polynomial. |
| scalar3 | specifies the number of periods of distributed lag. |
| pdlrestriction | specifies the zero restriction for the "NEAR" or "FAR" endpoints: NEAR, FAR, BOTH, or NONE. |

The regression format shows the coefficient and standard deviation for each term of the lag structure as well as for the overall sum, plus the average lag length. The t-statistic is given for the overall sum as well. Note that the backward slash "\" is a lag operator, e.g. "\1" indicates "lagged one period."

Overall statistics given are the R-squared adjusted for degrees of freedom, the Durbin-Watson statistic, and the standard error of the regression.

# UNBLEACHED KRAFT PAPERS

```
QUARTERLY(1968:1 TO 1980:2)    50 OBSERVATIONS
DEPENDENT VARIABLE:    UPPTOTEUF

          COEFFICIENT    STD. ERROR     T-STAT     INDEPENDENT VAR

            1747.41         99.09        17.63     CONSTANT

 1)                                                PDL(UPPRELPCN\1,
  \1      -164.560          14.07                       1,7,FAR)
  \2      -141.051          12.06
  \3      -117.543          10.05
  \4      -94.0343          8.041
  \5      -70.5257          6.031
  \6      -47.0172          4.021
  \7      -23.5086          2.010
  SUM     -658.240          56.29       -11.69
  AVG      2.00000            0.0          NC

 2)                                                PDL(WRPRELPLA\5,
  \5      -84.1064          19.10                       1,3,FAR)
  \6      -56.0709          12.73
  \7      -28.0355          6.366
  SUM     -168.213          38.19       -4.404
  AVG     0.666667            0.0

R-BAR SQUARED:   0.7429
DURBIN-WATSON STATISTIC:   0.1557
STANDARD ERROR OF THE REGRESSION:   28.74    NORMALIZED:   0.03735
```

DEFINITIONS OF VARIABLES:

UPPTOTEUF = UPPTOTAPC * UPPTOTENDUSE

UPPTOTAPC = Apparent consumption of Unbleached Kraft Paper

UPPTOTENDUSE = Industrial production index - weighted average of food, chemicals, cement, clay and glass; and nondurable manufacturing; and personal consumption expenditures on food.

UPPRELPCN = WPIUPPTOT/PCN

WPIUPPTOT = Wholesale price index - weighted average of wrapping paper, unbleached shipping sock, unbleached converted paper, unbleached grocer's bag.

PCN = Price deflater - consumer nondurables

WRPRELPLA = WPIO9130151NS/WPIO66NS

WPIO9130151NS= Wholesale price index - wrapping paper

WPIO66NS = Wholesale price index - plastic

# BLEACHED KRAFT PAPERS

```
QUARTERLY(1968:1 TO 1980:2)    50 OBSERVATIONS
DEPENDENT VARIABLE:    BPPTOTEUF

        COEFFICIENT    STD. ERROR     T-STAT   INDEPENDENT VAR.

          484.712        44.17         10.97   CONSTANT

 1)                                            PDL(UPPRELPCN\1,1,
  \1       -60.1416       6.272                      7,FAR)
  \2       -51.5500       5.376                          .
  \3       -42.9583       4.480                          .
  \4       -34.3666       3.584                          .
  \5       -25.7750       2.688                          .
  \6       -17.1833       1.792                          .
  \7       -8.59166      0.8961                          .
  SUM      -240.567       25.09        -9.588
  AVG       2.00000         0.0          NC
                                             PDL(WRPRELPLA\5,
 2)                                                1,3,FAR)
  \5       -32.4341       8.512
  \6       -21.6228       5.675
  \7       -10.8114       2.837
  SUM      -64.8683       17.02        -3.810
  AVG      0.666667         0.0

R-BAR SQUARED:  0.6563
DURBIN-WATSON STATISTIC:  0.1111
STANDARD ERROR OF THE REGRESSION:  12.81   NORMALIZED:  0.1038
```

DEFINITIONS OF VARIABLES

BPPTOTEUF = BPPTOTAPC/BPPTOTENDUSE

BPPTOTAPC = Apparent consumption of Bleached Kraft Papers

BPPTOTENDUSE = Industrial production index - weighted average of food; chemicals; cement, clay and glass; nondurable and all manufacturing; and personal consumption expenditures on retail merchandise and food

BPPTOTRELPCN = WPIUPPTOT/PCN

WPIUPPTOT = Wholesale price index - weighted average of wrapping paper, unbleached shipping stock, unbleached converted paper, unbleached grocer's bag

PCN = Price deflator - consumer nondurables

WRPRELPLA = WPI0913015lNS/WPI066NS

WPI0913015lNS = Wholesale price index - wrapping paper

WPI066NS = Wholesale price index - plastic

## GLASSINE AND GREASEPROOF

```
ANNUAL(1966 TO 1978)   13 OBSERVATIONS
DEPENDENT VARIABLE:    GGRTOTEUF

          COEFFICIENT    STD. ERROR     T-STAT    INDEPENDENT VAR.

            0.579684       0.1573        3.684    CONSTANT

 1)                                               PDL(WPIGGR%PGNP,
  \0      -0.0953238     0.02940                       1,2,FAR)
  \1      -0.0476619     0.01470
  SUM     -0.142986      0.04410        -3.242
  AVG      0.333333          0.0            NC

 2)                                               PDL(WPIGGR%WPIPLA,
                                                       1,2,FAR)
  \0      -0.131120      0.06856
  \1      -0.0655601     0.03428
  SUM     -0.196680       0.1028        -1.912
  AVG      0.333333          0.0

R-BAR SQUARED:   0.4263
DURBIN-WATSON STATISTIC:   1.7147
STANDARD ERROR OF THE REGRESSION:   0.01662   NORMALIZED:   0.09005
```

DEFINITIONS OF VARIABLES

GGRTOTEUF = GGRTOTPRO/GNP72

GGRTOTPRO = Shipment of Glassine and Greaseproof ($10^3$ ton/yr)

GNP72 = GNP in 1972 $

WPIGGR%PGNP = WPIGGR/PGNP

WPIGGR = Wholesale price index - Glassine and Greaseproof

PGNP = GNP deflator (1972 = 1.00)

WPIGGR%WPIPLA = WPIGGR/WPI066NS

WPI966NS = Wholesale price index for plastics

```
ANNUAL(1966 TO 1978)    13 OBSERVATIONS
DEPENDENT VARIABLE:     SIPTOTEUF

         COEFFICIENT    STD. ERROR     T-STAT     INDEPENDENT VAR.

           0.708973       0.1687        4.202     CONSTANT

 1)                                               PDL(WPISIP%PGNP,1,
  \0      -0.168255     0.09446                        2,FAR)
  \1      -0.0841277    0.04723
  SUM     -0.252383      0.1417        -1.781
  AVG      0.333333         0.0

R-BAR SQUARED:   0.1533
DURBIN-WATSON STATISTIC:   1.7518
STANDARD ERROR OF THE REGRESSION:   0.04472   NORMALIZED:   0.1093
```

DEFINITIONS OF VARIABLES

SIPTOTEUF = SIPTOTPRO/GNP72

SIPTOTPRO = Production of Special Industrial Papers ($10^3$ tons/yr)

GNP72 = GNP in 1972 $

WPISIP%PGNP = WPISIP/PGNP

WPISIP = Wholesale price index for S.I.P.

PGNP = GNP deflator (1972 = 1.00)

## NEWSPRINT

```
QUARTERLY(1966:1 TO 1980:1)    57 OBSERVATIONS
DEPENDENT VARIABLE:    EUFNEW@US

           COEFFICIENT    STD. ERROR     T-STAT     INDEPENDENT VAR.

               4.49212        0.6994      6.423     CONSTANT

  1)                                                PDL(JADVLIN@NPA,
   \0       0.00766722     0.0009058                    2,4,FAR)
   \1       0.00446754     0.0001837
   \2       0.00212311     0.0005387
   \3      0.000633929     0.0005076
   SUM       0.0148918     0.0006125      24.31
   AVG        0.712845        0.1806      3.946

  2)                                                PDL(NEWRELPAP,
   \0        -0.996395        0.3178                    1,3,FAR)
   \1        -0.664263        0.2118
   \2        -0.332132        0.1059
   SUM        -1.99279        0.6355     -3.136
   AVG        0.666667           0.0

  3)          -1.81540        0.2843     -6.385     NEW73DUM

  4)         -0.522286        0.1149     -4.547     NEW6669DUM

R-BAR SQUARED:   0.9665
DURBIN-WATSON STATISTIC:   0.9525
STANDARD ERROR OF THE REGRESSION:    0.3011    NORMALIZED: 0.01425
```

DEFINITIONS OF VARIABLES

EUFNEW@US = NEWTOTC@US/JCIRNPA@US

NEWTOTC@US = U.S. consumption of Newsprint ($10^3$ tons/qtr)

JCIRNPA@US = Circulation index weighted by ad lineage

JADVLIN@NPA = Index of newspaper advertizing lines

NEWRELPAP = WPI09130291/JTOT$%PAP@NPA

WPI09130291 = Wholesale price index of Newsprint, s.a.

JTOT$%PAP@NPA = Newspaper revenue index

NEW73DUM = Dummy variable for newspaper strikes

NEW6669DUM = Dummy variable for temporary strong demand

# UNCOATED FREESHEET

```
QUARTERLY(1963:1 TO 1979:2)    66 OBSERVATIONS
DEPENDENT VARIABLE:    UFSKRTEUF

         COEFFICIENT    STD. ERROR     T-STAT     INDEPENDENT VAR.

           1.57310        0.1136        13.85     CONSTANT

 1)                                               PDL(UFS%UGWPRC\1,
  \1      -0.0172566     0.02996                       2,8,FAR)
  \2      -0.0270584     0.01581
  \3      -0.0334433    0.007306
  \4      -0.0364115    0.008904
  \5      -0.0359628     0.01275
  \6      -0.0320973     0.01422
  \7      -0.0248150     0.01266
  \8      -0.0141159    0.007937
  SUM      -0.221161     0.04344       -5.091
  AVG        3.41480       1.299        2.629

 2)                                               PDL(UFSTOTRPR\1,
  \1     -0.00122206   0.0001908                      2,6,BOTH)
  \2     -0.00203677   0.0003180
  \3     -0.00244413   0.0003816
  \4     -0.00244413   0.0003816
  \5     -0.00203677   0.0003180
  \6     -0.00122206   0.0001908
  SUM     -0.0114059    0.001781       -6.406
  AVG        2.50000         0.0

 3)       0.00174551   0.0001992        8.763     GO51STOCK

R-BAR SQUARED:   0.9395
DURBIN-WATSON STATISTIC:   0.3165
STANDARD ERROR OF THE REGRESSION:   0.01882   NORMALIZED:   0.01547
```

DEFINITIONS OF VARIABLES

UFSKRTEUF = UFSKRTCON/GNP72

UFSKRTCON = Consumption of Uncoated Freesheet (including Kraft)

GNP72 = GNP in 1972 $

UFS%UGWTOTPRC = UFSTOTPRC/UGWTOTPRC

UFSTOTPRC = Average price of chemical wood pulp paper, uncoated book paper, cover and text paper, and kraft envelope paper weighted by shares in total production (¢/lb)

UGWTOTPRC = Price of Uncoated Groundwood (¢/lb)

UFSTOTRPR = UFSTOTPRC/PGNP

PGNP = Price deflator

## COATED PRINTING

### 1. Coated Two-Side No. 5

```
QUARTERLY(1968:1 TO 1978:3)    43 OBSERVATIONS
DEPENDENT VARIABLE:    CPRT05EUF

          COEFFICIENT    STD. ERROR     T-STAT     INDEPENDENT VAR.

           0.0290169    0.0009867       29.41     CONSTANT

 1)                                               PDL(CPRT05RPR\1,
  \1       -0.574695     0.09129                      2,6,BOTH)
  \2       -0.957825      0.1521                          .
  \3        -1.14939      0.1826                          .
  \4        -1.14939      0.1826                          .
  \5       -0.957825      0.1521                          .
  \6       -0.574695     0.09129                          .
  SUM       -5.36382      0.8520       -6.295
  AVG        2.50000         0.0

R-BAR SQUARED:   0.4791
DURBIN-WATSON STATISTIC:   0.2519
STANDARD ERROR OF THE REGRESSION:  0.001023   NORMALIZED:  0.04471
```

DEFINITIONS OF VARIABLES

CPRTO5EUF = CPRTO5CON/ADVPAG@MAG

CPRTO5CON = Consumption of No. 5 Coated Two-Side Printing Paper

ADVPAG@MAG = Magazine advertizing pages, s.a.

CPRTO5RPR = CPRTOTPRC/PAPVPAG@MAG

CPRTOTPRC = Total price of Coated Printing Papers (¢/lb.)

PADVPAG@MAG = Price of advertizing per magazine page

# COATED PRINTING

## 2. Coated Two-Side No. 14

```
QUARTERLY(1968:1 TO 1978:4)    44 OBSERVATIONS
DEPENDENT VARIABLE:    CPRT14EUF

         COEFFICIENT    STD. ERROR     T-STAT     INDEPENDENT VAR

            682.246        57.28        11.91     CONSTANT

 1)                                               PDL(CPRTOTRPR\1,
  \1        -1.74034      0.3745                       2,4,BOTH)
  \2        -2.61050      0.5617
  \3        -2.61050      0.5617
  \4        -1.74034      0.3745
  SUM       -8.70168       1.872       -4.648
  AVG        1.50000         0.0

 2)                                               PDL(CPR%UGWTOTPRC\1,
                                                      2,6,BOTH)
  \1        -7.84477       4.962
  \2        -13.0746       8.270
  \3        -15.6895       9.924
  \4        -15.6895       9.924
  \5        -13.0746       8.270
  \6        -7.84477       4.962
  SUM       -73.2178       46.31       -1.581
  AVG        2.50000         0.0

 3)                                               PDL(PMZ%PNTV\1,2,
  \1        -53.0115       15.20                       8,FAR) .
  \2        -48.0011       8.083
  \3        -42.5289       5.024
  \4        -36.5950       6.548
  \5        -30.1994       8.366
  \6        -23.3421       8.839
  \7        -16.0231       7.651
  \8        -8.24242       4.715
  SUM       -257.944       33.31       -7.744
  AVG        2.45863       82.42      0.02983

R-BAR SQUARED:   0.9195
DURBIN-WATSON STATISTIC:   0.1330
STANDARD ERROR OF THE REGRESSION:   10.60   NORMALIZED:   0.04382   .
```

DEFINITIONS OF VARIABLES

CPRT14EUF = CPRT14CON/JQINDCPRT14

CPRT14CON = Consumption of Coated Two-Side No. 14 Printing Paper

JQINDCPRT14 = Industrial Production index - Coated Two-Side No. 14

CPRTOTRPR = CPRTOTPRC/JAHE27

CPRTOTPRC = Total cost of Coated Printing Paper (¢/lb.)

JAHE27 = Index of average hourly earnings; printing and publishing, s.a.

CPR%UGWTOTPRC = CPRTOTPRC/UGWTOTPRC

UGWTOTPRC = Price of Uncoated Groundwood (¢/lb.)

PMZ%PNTV = Relative price index of magazine advertizing to network advertizing

## COATED PRINTING

### 3. Coated One-Side

```
QUARTERLY(1962:2 TO 1978:3)    66 OBSERVATIONS
DEPENDENT VARIABLE:    CPROSIEUF

             COEFFICIENT    STD. ERROR     T-STAT    INDEPENDENT VAR.

               224.452         12.87        17.44    CONSTANT

 1)                                                  PDL(CPROSIRPR\1,
  \1         -0.374704      0.09240                .      2,4,BOTH)
  \2         -0.562057       0.1386                .
  \3         -0.562057       0.1386                .
  \4         -0.374704      0.09240                .
  SUM         -1.87352       0.4620       -4.055
  AVG          1.50000          0.0

 2)           -25.3353        1.895       -13.37     LOG(TIME)

R-BAR SQUARED:   0.7403
DURBIN-WATSON STATISTIC:  0.0244
STANDARD ERROR OF THE REGRESSION:  2.781   NORMALIZED:  0.03293
```

DEFINITIONS OF VARIABLES

CPROSIEUF = CPROSICON/JQINDOSI

CPROSICON = Consumption of Coated One-Side Printing Paper

JQINDOSI = Industrial production index - Coated One-Side Paper

CPROSIRPR = CPRTOTPRC/WPIOSI

CPRTOTPRC = Total price of Coated Printing Papers (¢/lb)

WPIOSI = Wholesale price index - weighted, Coated One-Side Paper

UNCOATED GROUNDWOOD

```
QUARTERLY(1968:1 TO 1978:2)   42 OBSERVATIONS
DEPENDENT VARIABLE:   UGWTOTEUF

          COEFFICIENT   STD. ERROR    T-STAT    INDEPENDENT VAR.

            1285.23       93.87       13.69     CONSTANT

 1)                                             PDL(JPADV@NPA%PNTV\1,
                                                 2,6,FAR)
  \1      -3525.92        1999                       .
  \2      -5268.92       917.3                       .
  \3      -6079.66       874.9                       .
  \4      -5958.14        1175                       .
  \5      -4904.35        1184                       .
  \6      -2918.31       799.6                       .
  SUM     -28655.3        3812      -7.517
  AVG      2.42579        9248   0.0002623

 2)                                             PDL(UGW%NEWTOTPRC\1,
                                                 2,8,FAR)
  \1      -111.088       16.63                            .
  \2      -84.3175       10.45                            .
  \3      -61.2280       6.907                            .
  \4      -41.8199       6.360                            .
  \5      -26.0932       7.049                            .
  \6      -14.0478       7.217                            .
  \7      -5.68381       6.218                            .
  \8      -1.00121       3.839
  SUM     -345.280       40.89      -8.445
  AVG      1.58699       65.18     0.02435

 3)                                             PDL(UGW%UBPTOTPRC\1,
                                                 2,8,BOTH)
  \1      -25.0923       3.652                             .      .
  \2      -43.9115       6.391                             .
  \3      -56.4576       8.217                             .
  \4      -62.7307       9.129                             .
  \5      -62.7307       9.129                             .
  \6      -56.4576       8.217                             .
  \7      -43.9115       6.391                             .
  \8      -25.0923       3.652                             .
  SUM     -376.384       54.78      -6.871
  AVG      3.50000         0.0

R-BAR SQUARED:   0.7991
DURBIN-WATSON STATISTIC:   0.3218
STANDARD ERROR OF THE REGRESSION:   9.129   NORMALIZED:   0.03393
```

# UNCOATED GROUNDWOOD

DEFINITIONS OF VARIABLES

UGWTOTEUF = UGWTOTCON/JQIND27ENW

UGWTOTCON = Consumption of Uncoated Groundwood Papers

JQIND27ENW = Industrial production index - printing and publishing excluding newspapers

JPADV@NPA%PNTV = Relative price index of newspaper advertising and national TV advertising

UGW%NEWTOTPRC = UGWTOTPRC/NEWTOTPRC

UGWTOTPRC = Price of Uncoated Groundwood (¢/lb.)

NEWTOTPRC = Price of Newsprint (¢/lb.)

UGW%UBPTOTPRC = UGWTOTPRC/UBPTOTPRC

UBPTOTPRC = Price of Uncoated Book Papers (¢/lb.)

## THIN PAPERS

### 1. Carbonizing

```
QUARTERLY(1967:1 TO 1978:3)   47 OBSERVATIONS\          VAR.
DEPENDENT VARIABLE: THICAREUF

          COEFFICIENT    STD. ERROR    T-STAT

             9.71808        1.249       7.778         CONSTANT

 1)        -0.499732       0.1505      -3.321

 2)                                                  PDL(THIRPRPGNP\1,2,6,
                                                      BOTH)
  \1      -0.00393658     0.001299                        .
  \2      -0.00656097     0.002164                        .
  \3      -0.00787316     0.002597                        .
  \4      -0.00787316     0.002597                        .
  \5      -0.00656097     0.002164                        .
  \6      -0.00393658     0.001299                        .
  SUM      -0.0367414      0.01212     -3.031
  AVG         2.50000          0.0        NC

 3)                                                  PDL(THIRPRCWP\3,
  \3       -0.251057      0.08110                     2,6,BOTH)
  \4       -0.418429       0.1352                         .
  \5       -0.502115       0.1622                         .
  \6       -0.502115       0.1622                         .
  \7       -0.418429       0.1352                         .
  \8       -0.251057      0.08110                         .
  SUM        -2.34320       0.7569     -3.096
  AVG         2.50000          0.0

R-BAR SQUARED:   0.6886
DURBIN-WATSON STATISTIC:   0.0866
STANDARD ERROR OF THE REGRESSION:   0.1134   NORMALIZED:   0.03170
```

DEFINITIONS OF VARIABLES

THICAREUF = THICARCON/(GNP72 / 100)

THICARCON = Consumption of Carbonizing Thin Papers

GNP72 = GNP in 1972 $

TIME = Time trend

THIRPRPGNP = THITOTPRC/PGNP

THITOTPRC = Price of Thin Papers (¢/lb.)

PGNP = GNP deflator (1972 = 1.00)

THIRPRCWP = THITOTPRC/CWPTOTPRC

CWPTOTPRC = Price of Chemical Wood Pulp Papers (¢/lb.)

## THIN PAPERS

### 2. Other

```
QUARTERLY(1965:3 TO 1978:3)    53 OBSERVATIONS
DEPENDENT VARIABLE:    THIOTHEUF

          COEFFICIENT    STD. ERROR     T-STAT     INDEPENDENT VAR.

             4.47190       0.1654        27.03     CONSTANT

 1)        -0.288291       0.03069      -9.392     LOG(TIME)

 2)                                                PDL(THIRPRPGNP\1,
                                                        2,6,BOTH)
  \1     -0.00209778    0.0001776                        .
  \2     -0.00349631    0.0002959                        .
  \3     -0.00419557    0.0003551                        .
  \4     -0.00419557    0.0003551                        .
  \5     -0.00349631    0.0002959                        .
  \6     -0.00209778    0.0001776                        .
  SUM     -0.0195793     0.001657      -11.82
  AVG        2.50000          0.0

R-BAR SQUARED:   0.7496
DURBIN-WATSON STATISTIC:   0.1844
STANDARD ERROR OF THE REGRESSION:   0.03020   NORMALIZED:   0.01138
```

DEFINITIONS OF VARIABLES

THIOTHEUF = THIOTHCON/(GNP72/100)

THIOTHCON = Consumption of Other Thin Papers

GNP72 = GNP in 1972 $

TIME = Time trend

THIRPRPGNP = THITOTPRC/PGNP

THITOTPRC = Price of Thin Papers (¢/lb.)

PGNP = GNP deflator (1972 = 1.00)

## SOLID BLEACHED BRISTOLS

### 1. Total (exc. Tabulating)

```
QUARTERLY(1966:1 TO 1978:3)    51 OBSERVATIONS
DEPENDENT VARIABLE:    BRITOTEUF

          COEFFICIENT    STD. ERROR     T-STAT    INDEPENDENT VAR

            0.179049      0.01572       11.39     CONSTANT

 1)
  \1    -0.00197269   0.0005397                  PDL(BRITOTRPR,1,
  \2    -0.00328781   0.0008996                      2,6,BOTH)
  \3    -0.00394537    0.001079                         .
  \4    -0.00394537    0.001079                         .
  \5    -0.00328781   0.0008996                         .
  \6    -0.00197269   0.0005397                         .
  SUM     -0.0184117    0.005038      -3.655            .
  AVG        2.50000         0.0

 2)     -0.00399828    0.002659      -1.504     LOG(TIME)

R-BAR SQUARED:   0.1851
DURBIN-WATSON STATISTIC:   0.0932
STANDARD ERROR OF THE REGRESSION:  0.002548   NORMALIZED:  0.01841
```

**DEFINITIONS OF VARIABLES**

**BRITOTEUF** = BRITOTCON/GNP72

**BRITOTCON** = Consumption of Solid Bleached Bristols

**GNP72** = GNP in 1972 $

**BRITOTRPR** = WPI09150645/PGNP

**WPI09150645** = Wholesale price index - file folders, s.a.

**PGNP** = GNP deflator (1972 = 1.00)

**TIME** = Time trend

## SOLID BLEACHED BRISTOLS

### 2. Tabulating

```
QUARTERLY(1966:1 TO 1978:3)    51 OBSERVATIONS
DEPENDENT VARIABLE:    BRITABEUF

           COEFFICIENT    STD. ERROR     T-STAT    INDEPENDENT VAR.

             0.974226      0.04118        23.66    CONSTANT

 1)                                                PDL(BRITOTRPR\1,
   \1     -0.00528312     0.001414                    2,6,BOTH)
   \2     -0.00880520     0.002357                       .
   \3      -0.0105662     0.002828                       .
   \4      -0.0105662     0.002828                       .
   \5     -0.00880520     0.002357                       .
   \6     -0.00528312     0.001414                       .
  SUM      -0.0493091      0.01320       -3.736
  AVG         2.50000          0.0

 2)         -0.176298     0.006967       -25.31    LOG(TIME)

R-BAR SQUARED:  0.9322
DURBIN-WATSON STATISTIC:  0.0753
STANDARD ERROR OF THE REGRESSION:  0.006677   NORMALIZED:  0.06588
```

DEFINITIONS OF VARIABLES

BRITABEUF = BRITABCON/GNP72

BRITABCON = Consumption of Solid Bleached Bristols - Tabulating

GNP72 = GNP in 1972 $

BRITOTRPR = WPI09150645/PGNP

WPI09150645 = Wholesale price index - file folders, s.a.

PGNP = GNP deflator (1972 = 1.00)

TIME = Time trend

## COTTON FIBRE

```
QUARTERLY(1974:1 TO 1978:4)   20 OBSERVATIONS
DEPENDENT VARIABLE:   COTTOTEUF

        COEFFICIENT   STD. ERROR    T-STAT    INDEPENDENT VAR.

           6.61346      0.7148       9.253    CONSTANT

 1)                                           PDL(COTTOTRPR\1,
  \1     -0.00360731   0.004434                  2,8,FAR)
  \2     -0.00604699   0.002761                      .
  \3     -0.00766079   0.001627                      .
  \4     -0.00844870   0.001238                      .
  \5     -0.00841073   0.001378                      .
  \6     -0.00754687   0.001487                      .
  \7     -0.00585713   0.001330                      .
  \8     -0.00334151   0.0008419                     .
  SUM    -0.0509200    0.008945     -5.693
  AVG        3.46868     0.5840  .   5.940

 2)                                           PDL(COT%CWPPRC\1,
  \1       -0.376449      0.1811          .        2,4,FAR)
  \2       -0.256150     0.06081          .
  \3       -0.153308      0.1093          .
  \4      -0.0679249     0.09890          .
  SUM      -0.853832      0.2027    -4.212
  AVG       0.897765      0.7608     1.180

 R-BAR SQUARED:   0.8071
 DURBIN-WATSON STATISTIC:   0.4549
 STANDARD ERROR OF THE REGRESSION:  0.07106   NORMALIZED:  0.03460
```

DEFINITIONS OF VARIABLES

COTTOTEUF = COTTOTCON/(GNP72/100)

COTTOTCON = Consumption of Cotton Fibre Paper

GNP72 = GNP in 1972 $

COTTOTRPR = COTTOTPRC/PGNP

COTTOTPRC = Price of Cotton Fibre Paper (¢/lb.)

PGNP = GNP Deflator (1972 = 1.00)

COT%CWPPRC = COTTOTPRC/CWPTOTPRC

CWTOTPRC = Price of Chemical Wood Pulp Papers (¢/lb.)

## TISSUES

```
QUARTERLY(1969:1 TO 1978:3)    39 OBSERVATIONS
DEPENDENT VARIABLE:    TISTOTEUF

          COEFFICIENT   STD. ERROR     T-STAT    INDEPENDENT VAR.

             14.0979     0.02476        569.5    CONSTANT

 1)                                              PDL(TISRELPCN,
  \0      -0.217488    0.003606            .          1,3,FAR)
  \1      -0.144992    0.002404            .
  \2      -0.0724959   0.001202            .
  SUM     -0.434975    0.007211       -60.32
  AVG      0.666667         0.0

 2)                                              PDL(EM%HH,1,
  \0        1.85105     0.03918    .                  2,FAR)
  \1       0.925526     0.01959    .
  SUM       2.77658     0.05877        47.24
  AVG      0.333333         0.0

R-BAR SQUARED:   0.9984
DURBIN-WATSON STATISTIC:   0.9550
STANDARD ERROR OF THE REGRESSION:   0.005127   NORMALIZED:   0.0003587
```

DEFINITIONS OF VARIABLES

TISTOTEUF = TISTOTCON/HH

TISTOTCON = Consumption of Tissues

HH = Total U.S. households - millions

TISRELPCN = WPI091501/PCN

WPI091501 = Wholesale price index - Tissues s.a.

PCN = Price deflator - consumer nondurables

EM%HH = EM/HH

EM = Employment - manufacturing

## FIBRE BOXBOARD

### 1. Group 2

```
QUARTERLY(1970:1 TO 1980:2)    42 OBSERVATIONS
DEPENDENT VARIABLE:   FSJQGR2

             COEFFICIENT      STD. ERROR        T-STAT       INDEPENDENT VARIABLE

               6351.01          757.4            8.385       CONSTANT

                                                             PDL(FIBRPRPLA 1,2,8,BOTH)

1)
  \1         -8.89338         2.787
  \2         -15.5634         4.877
  \3         -20.0101         6.270
  \4         -22.2334         6.967
  \5         -22.2334         6.967
  \6         -20.0101         6.270
  \7         -15.5634         4.877
  \8         -8.89338         2.787
  SUM        -133.401         41.80             -3.191
  AVG         3.50000           0.0

 R-BAR SQUARED:   0.1830
 DURBIN-WATSON STATISTIC:   0.1532
 STANDARD ERROR OF THE REGRESSION:   288.9   NORMALIZED:   0.07336
```

DEFINITIONS OF VARIABLES

FSJQGR2 = FIBSHPGR2/JQINDGR2

FIBSHPGR2 = Fibre Box shipments, Group 2

JQINDGR2 = Industrial production index, Group 2

FIBRPRPLA = FIBTOTPRCNS/WPI066NS

FIBTOTPRCNS = National corrugated price ($/m.s.f.)

WPI066NS = Wholesale price index - plastics

## FIBRE BOXBOARD

### 2. Group 3 - Producer Durables

```
 QUARTERLY(1966:1 TO 1976:4)    44 OBSERVATIONS
 DEPENDENT VARIABLE:    FSJQGR3PDUR

         COEFFICIENT   STD. ERROR    T-STAT     INDEPENDENT VAR.

            33377.0         1245      26.82     CONSTANT

  1)                                            PDL(FIBGR3RPR\2,
   \2        122.258      85.15               .          2,5,FAR)
   \3       -209.362      24.83               .
   \4       -387.397      30.56               .
   \5       -411.849      44.08               .
   \6       -282.716      34.42               .
   SUM      -1169.07      75.16      -15.55
   AVG           NM

 R-BAR SQUARED:   0.8585
 DURBIN-WATSON STATISTIC:  1.1497
- STANDARD ERROR OF THE REGRESSION:  434.3   NORMALIZED:  0.03091
```

DEFINITION OF VARIABLES

FSJQGR3PDUR = FIBSHPGR3PDUR/JQINDGR3PDUR

FIBSHPGR3PDUR = Fibre Box shipments, Group 3, producer durables

JQINDGR3PDUR = Industrial production index, Group 3, producer durables

FIBGR3RPR = FIBTOTPRC/WPI11

FIBTOTPRC = National corrugated price (¢/M.S.F.), s.a.

WPI11 = Wholesale price index - machinery and equipment, s.a.

## FIBRE BOXBOARD

### 3. Group 4 - Consumer Durables

```
QUARTERLY(1972:3 TO 1977:1)    19 OBSERVATIONS
DEPENDENT VARIABLE:    FSJQGR4CDUR

          COEFFICIENT    STD. ERROR     T-STAT     INDEPENDENT VAR.

             299510         5135        58.33     CONSTANT

 1)        -49296.3         1207       -40.84     LOG(TIME)

 2)        -1.00032      0.03431       -29.16 (801◆(FIBTOTPRC\1/WPIIND\
                                              1)+ 967◆(FIBTOTPRC\2/
                                              WPIIND\2)+888◆
                                              (FIBTOTPRC\3/WPIIND\3)+
                                              566◆(FIBTOTPRC\4/WPIIND\
                                              4))

R-BAR SQUARED:  0.9961
DURBIN-WATSON STATISTIC:  1.0051
STANDARD ERROR OF THE REGRESSION:  229.4   NORMALIZED:  0.01497
```

DEFINITION OF VARIABLES

FSJQGR4CDUR = FIBSHPGR4CDUR/JQINDGR4CDUR

FIBSHPGR4CDUR = Fibre Box shipments, Group 4, consumer durables

JQINDGR4CDUR = Industrial production index, Group 4, consumer durables

TIME = Time trend

FIBTOTPRC = National corrugated price ($/M.S.F.), s.a.

WPIIND = Wholesale price index - industrial commodities, s.a.

FIBRE BOXBOARD

## 4. Group 4 - Consumer Nondurables

```
QUARTERLY(1963:1 TO 1980:4)    72 OBSERVATIONS
DEPENDENT VARIABLE:    FSJQGR4NDUR

          COEFFICIENT    STD. ERROR     T-STAT     INDEPENDENT VAR.

              14547.8         532.5      27.32     CONSTANT

 1)          -2126.82         115.9     -18.34     LOG (TIME)

R-BAR SQUARED:  0.8253
DURBIN-WATSON STATISTIC:  0.2404
STANDARD ERROR OF THE REGRESSION:  209.9   NORMALIZED:  0.04383
```

DEFINITIONS OF VARIABLES

FSJQGR4NDUR = FIBSHPGR4NDUR/JQINDGR4NDUR

FIBSHPGR4NDUR = Fibre Box shipments, Group 4, consumer nondurables

JQINDGR4NDUR = Industrial production index, Group 4, consumer nondurables

TIME = Time trend

## FIBRE BOXBOARD

### 5. Group 4 - Producer Durables

```
QUARTERLY(1968:1 TO 1976:4)    36 OBSERVATIONS
DEPENDENT VARIABLE:    FSJQGR4PDUR

          COEFFICIENT    STD. ERROR     T-STAT     INDEPENDENT VAR.

             20819.9          1782       11.69     CONSTANT

 1)         -2166.55         403.3      -5.372     LOG(TIME)

 2)                                                PDL(DJQGR4PDURL,
  \0        -59.6307         104.8           .         2,4,FAR)
  \1        -166.933         72.67           .
  \2        -192.762         78.51           .
  \3        -137.118         59.56           .
  SUM       -556.443         242.2      -2.297
  AVG        1.73209        0.4130       4.194    (18◆(FIBTOTPRC\1/
                                                   WPI066NS\1)+9◆
 3)         -1.02811        0.6044      -1.701     (FIBTOTPRC\2/WPI

                                                    066NS\2)(


R-BAR SQUARED:   0.6124
DURBIN-WATSON STATISTIC:   0.3784
STANDARD ERROR OF THE REGRESSION:   207.2   NORMALIZED:   0.02705
```

DEFINITIONS OF VARIABLES

FSJQGR4PDUR = FIBSHPGR4PDUR/JQIND22

FIBSHPGR4PDUR = Fibre Box shipments, Group 4, producer durables

JQIND22 = Industrial production index, Group 4, producer durables

TIME = Time trend

DJQGR4DURL = (JQINDGR4PDUR/JQINDGR4PDUR/1) * LOG(TIME)

WPI066NS = Wholesale price index - plastics

## FIBRE BOXBOARD

### 6. Group 5 - Consumer Nondurables

```
QUARTERLY(1973:1 TO 1976:4)    16 OBSERVATIONS
DEPENDENT VARIABLE:    FSJQGR5NDUR

           COEFFICIENT    STD. ERROR      T-STAT     INDEPENDENT VAR.

                356692    2.386E+04        14.95     CONSTANT

 1)           -67401.0         4834       -13.94     LOG(TIME)

 2)           -1.23819       0.2137       -5.794     FIBRPRSUBL3

R-BAR SQUARED:   0.9288
DURBIN-WATSON STATISTIC:   1.7381
STANDARD ERROR OF THE REGRESSION:   674.1   NORMALIZED:   0.02439
```

DEFINITIONS OF VARIABLES

FSJQGR5NDUR = FIBSHPGR5NDUR/JQINDGR5NDUR

FIBSHPGR5NDUR = Fibre Box shipments, Group 5, consumer nondurables

JQINDGR5NDUR = Industrial production index, Group 5, consumer nondurables

TIME = Time trend

FIBRPRSUBL3 = Polynomial distributed lag, over FIBTOTPRC/WPI066NS (lagged 2 to 8 quarters)

FIBTOTPRC = National corrugated price ($/M.S.F.), s.a.

WPI066NS = Wholesale price index - plastics

## FIBRE BOXBOARD

### 7. Group 5 - Producer Durables

```
QUARTERLY(1973:1 TO 1976:4)    16 OBSERVATIONS
DEPENDENT VARIABLE:    FSJQGR5PDUR

           COEFFICIENT    STD. ERROR     T-STAT     INDEPENDENT VAR.

              75765.8         3918        19.34     CONSTANT

 1)          -14295.6        797.5       -17.93     LOG(TIME)

 2)                                                 PDL(FIBRPRSUB\4,
  \4          43.1019        11.91                      2,4,FAR)
  \5         -15.0560        3.804          .
  \6         -41.6256        6.286          .
  \7         -36.6070        5.804          .
  SUM        -50.1867        12.68       -3.958
  AVG           NM

R-BAR SQUARED:   0.9775
DURBIN-WATSON STATISTIC:   1.0245
STANDARD ERROR OF THE REGRESSION:   92.35   NORMALIZED:   0.01274
```

DEFINITIONS OF VARIABLES

FSJQGR5PDUR = FIBSHPGR5PDUR/JQINDGR5PDUR

FIBSHPGR5PDUR = Fibre Box shipments, Group 5, producer durables

JQINDGR5PDUR = Industrial production index, Group 5, producer durables

TIME = Time trend

FIBRPRSUB = Polynomial distributed lag (4th to 7th quarters) over FIBTOTPRC/WPI066NS

FIBTOTPRC = National corrugated price ($/M.S.F.), s.a.

WPI066NS = Wholesale price index - plastics

## BLEACHED FOLDINGBOARD

```
QUARTERLY(1970:2 TO 1979:3)    38 OBSERVATIONS
DEPENDENT VARIABLE:FLDBKBEUF

          COEFFICIENT    STD. ERROR     T-STAT    INDEPENDENT VAR.

              2.22357        0.1200      18.53    CONSTANT

 1)          0.894959       0.08455      10.59    PENRATE

 2)                                               PDL(BKBPRC%PCNBOX\1,
                                                     2,6,BOTH)
  \1   -0.000531004   6.308E-05                         .
  \2   -0.000885006   0.0001051                         .
  \3    -0.00106201   0.0001262                         .
  \4    -0.00106201   0.0001262                         .
  \5   -0.000885006   0.0001051                         .
  \6   -0.000531004   6.308E-05                         .
  SUM   -0.00495603   0.0005888     -8.418
  AVG       2.50000         0.0

R-BAR SQUARED:   0.7495
DURBIN-WATSON STATISTIC:   0.2798
STANDARD ERROR OF THE REGRESSION:   0.02614   NORMALIZED:   0.01842
```

DEFINITIONS OF VARIABLES

FLDBKBEUF = FLDBKBDCON/CNBOX72

FLDBKBDCON = Consumption of Bleached Foldingboard

CNBOX72 = Real personal consumption expenditure - weighted for folding boxboard

PENRATE = Proxy for penetration of Bleached for Recycled foldingboard

BKBPRC%PCNBOX= FLDBKBPRCNS/PCNBOX

FLDBKBPRCNS = Price of Bleached Foldingboard ($/ton)

PCNBOX = Implicit price deflator for consumer nondurables - weighted for boxboard

## RECYCLED FOLDINGBOARD

### 1. Recycled Foldingboard

```
QUARTERLY(1968:3 TO 1979:3)   45 OBSERVATIONS
DEPENDENT VARIABLE: FLDRCBEUF

          COEFFICIENT   STD. ERROR    T-STAT    INDEPENDENT VAR.

             5.46862       0.1152       47.45    CONSTANT

 1)                                              PDL(RCBPRC%FILM\1,
                                                     2,6,BOTH)
  \1     -0.00156300   6.853E-05                      .
  \2     -0.00260501   0.0001142                      .
  \3     -0.00312601   0.0001371                      .
  \4     -0.00312601   0.0001371                      .
  \5     -0.00260501   0.0001142                      .
  \6     -0.00156300   6.853E-05                      .
  SUM     -0.0145880   0.0006396      -22.81
  AVG        2.50000         0.0

 2)                                              PDL(RCBPRC%PCNBOX\1,
                                                    2,4,BOTH)
  \1    -0.000512447   0.0001174                 .
  \2    -0.000768671   0.0001760                 .
  \3    -0.000768671   0.0001760                 .
  \4    -0.000512447   0.0001174                 .
  SUM    -0.00256224   0.0005868      -4.367
  AVG        1.50000         0.0

R-BAR SQUARED:   0.9549
DURBIN-WATSON STATISTIC:   0.1142
STANDARD ERROR OF THE REGRESSION:  0.05666   NORMALIZED:  0.02592
```

DEFINITIONS OF VARIABLES

FLDRCBEUF = FLDRCBDCON/CNBOX72

FLDRCBDCON = Consumption of Recycled Foldingboard

CNBOX72 = Personal consumption expenditures - weighted folding boxboard

RCBPRC%FILM = FLDRCBPRCNS/WPI0722NS

FLDRCBPRCNS = Price of Recycled Foldingboard ($/ton)

WPI0722NS = Wholesale price index - unsupported plastic film & sheet

RCBPRC%PCNBOX = FLDRCBPRCNS/PCNBOX

PCNBOX = Implicit price deflator for consumer nondurables - weighted for boxboard

## RECYCLED FOLDINGBOARD

### 2. Setup Boxboard

```
Quarterly (1968:1 to 1980:2)   50 Observations
Dependent Variable: SETRCBEUF

              COEFFICIENT      STD. ERROR      T-STAT      IND. VARIABLE

               1.06404          0.05895        18.05        CONSTANT

1)                                                          PDL(SETRCBPRC%PCN\
                                                            1,2,4, BOTH)

\1          -0.0449996          0.01529
\2          -0.0674993          0.02293
\3          -0.0674993          0.02293
\4          -0.0449996          0.01529
 SUM          -0.224998          0.07645      -2.943
 AVG            1.50000              0.0

                                                            PDL(SETRCBPRC%PLA\
2)                                                          1,2,8,BOTH)
\1          -0.0248075          0.003755
\2          -0.0434131          0.006572
\3          -0.0558169          0.008449
\4          -0.0620188          0.009388
\5          -0.0620188          0.009388
\6          -0.0558169          0.008449
\7          -0.0434131          0.006572
\8          -0.0248075          0.003755
 SUM          -0.372113          0.05633      -6.606
 AVG            3.50000              0.0

  R-BAR SQUARED: 0.8401
  DURBIN-WATSON STATISTIC:  0.0637
  STANDARD ERROR OF THE REGRESSION:  0.03542   NORMALIZED:  0.1070
```

DEFINITIONS OF VARIABLES

SETRCBEUF = SETRCBDCON/CN72
SETRCBDCON = Consumption of Setup Boxboard
CN72 = Personal consumption expenditures - nondurables, in 1972 $
TIME = Time trend
SETRPRPCN = WPI091403NS/PCN
WPI019403NS = Wholesale price index - setup boxboard
PCN = Price deflator - consumer nondurables

## CONSTRUCTION PAPER AND BOARD

```
QUARTERLY(1968:1 TO 1978:3)   43 OBSERVATIONS
EPENDENT VARIABLE:   BPBTOTEUF

          COEFFICIENT   STD. ERROR    T-STAT    INDEPENDENT VAR.

            54.6569       0.1575       347.0    CONSTANT

 1)        -0.321510    0.001416      -227.0    ICR72

 2)                                             PDL(BPBRELPICR\1,1,
1       -3.47369     0.03162                      , 6,FAR)
 \2        -2.89474     0.02635                     .
 \3        -2.31579     0.02108                     .
 \4        -1.73684     0.01581                     .
 \5        -1.15790     0.01054                     .
 \6       -0.578948    0.005270                     .
 SUM      -12.1579      0.1107     -109.8
  AVG       1.66667        0.0

R-BAR SQUARED:  0.9992
DURBIN-WATSON STATISTIC:  0.8542
STANDARD ERROR OF THE REGRESSION:  0.07380   NORMALIZED:  0.002853
```

**DEFINITIONS OF VARIABLES**

BPBTOTEUF = BPBTOTCON/ICR72

BPBTOTCON = Consumption of Construction Paper and Board

ICR72 = Investment in residential structures in 1972 $

BPBRELPICR = WPI092/PICR

WPI092 = Wholesale price index - construction paper and board

PICR = Price deflator - residential investment

## SOLID BLEACHED BOARD

### 1. Milk Cartons

```
QUARTERLY(1970:1 TO 1979:4)    40 OBSERVATIONS
DEPENDENT VARIABLE:BKBMLKEUF

         COEFFICIENT    STD. ERROR     T-STAT    INDEPENDENT VAR.

             18.4970        1.175       15.74    CONSTANT

 1)                                              PDL(BKBPRC%CPIMILK\1,
                                                     2,4, FAR)
  \1     -0.00867894    0.003414                .
  \2     -0.00886765    0.001168                .
  \3     -0.00743407    0.001883                .
  \4     -0.00452819    0.001712                .
  SUM     -0.0295588    0.003892       -7.594
  AVG        1.26596      0.3210        3.943

 2)                                              PDL(BKBPRC%PLASTICSA\3,
                                                      2,3,BOTH)
  \3    -0.000352460   0.0002110                           .
  \4    -0.000616806   0.0003693                           .
  \5    -0.000793036   0.0004748                           .
  \6    -0.000881151   0.0005275                           .
  \7    -0.000881151   0.0005275                           .
  \8    -0.000793036   0.0004748                           .
  \9    -0.000616806   0.0003693                           .
  \10   -0.000352460   0.0002110                           .
  SUM    -0.00528691    0.003165       -1.670
  AVG        3.50000         0.0

R-BAR SQUARED:   0.7002
DURBIN-WATSON STATISTIC:   0.2506
STANDARD ERROR OF THE REGRESSION:   0.3108   NORMALIZED:   0.03247
```

DEFINITIONS OF VARIABLES

BKBMLKEUF = BKBMLKPRO/CNFOOD72

BKBMLKPRO = Production of milk cartons

CNFOOD72 = Personal consumption expenditures on food (1972$)

BKBPRC%CPIMILK = BKBTOTPRCNS/CPIW0901

BKBTOTPRCNS = Bleached Foldingboard price ($/ton)

CPIW091 = Consumer price index for milk

BKBPRC%PLABOT = BKBTOTPRCNS/WPI07250101

WPI07250101 = Wholesale price index - plastic bottles

## SOLID BLEACHED BOARD

### 2. Food Service

```
QUARTERLY(1970:2 TO 1979:4)    39 OBSERVATIONS
DEPENDENT VARIABLE: BKBFSVEUF

         COEFFICIENT    STD. ERROR     T-STAT     INDEPENDENT VAR.

             3.52226       0.1383       25.47     CONSTANT

 1)                                               PDL(BKBPRC%PCNFOOD\1,
                                                       2,6,BOTH)
  \1    -0.000193912    5.702E-05                          .
  \2    -0.000323186    9.503E-05                          .
  \3    -0.000387823    0.0001140                          .
  \4    -0.000387823    0.0001140                          .
  \5    -0.000323186    9.503E-05                          .
  \6    -0.000193912    5.702E-05                          .
  SUM    -0.00180984    0.0005322          -3.401
  AVG        2.50000          0.0

 2)                                               PDL(BKBPRC%PLADIN\3,
                                                     2,8,BOTH)
  \3    -8.61439E-05    1.379E-05                              .
  \4    -0.000150752    2.413E-05                              .
  \5    -0.000193824    3.102E-05                              .
  \6    -0.000215360    3.447E-05                              .
  \7    -0.000215360    3.447E-05                              .
  \8    -0.000193824    3.102E-05                              .
  \9    -0.000150752    2.413E-05                              .
  \10   -8.61439E-05    1.379E-05                              .
  SUM    -0.00129216    0.0002068          -6.248
  AVG        3.50000          0.0

R-BAR SQUARED:   0.6442
DURBIN-WATSON STATISTIC:   0.1346
STANDARD ERROR OF THE REGRESSION:   0.02186   NORMALIZED:   0.008679
```

DEFINITIONS OF VARIABLES

BKBFSVEUF = BKBFSVPRO/CNFOOD72

BKBFSVPRO = Production of cups, and food dish and tray

CNFOOD72 = Personal consumption expenditures on food (1972$)

BKBPRC%PCNFOOD = BKBTOTPRCNS/PCNFOOD

BKBTOTPRCNS = Price of Bleached Foldingboard ($/ton)

PCNFOOD = Implicit price deflator, consumption of food

BKBPRC%PLADIN = BKBTOTPRCNS/WPI0727

WPI7027 = Wholesale price index - plastic dinnerware

## ALL OTHER BOARD

### 1. Unbleached Other Board

```
QUARTERLY(1971:3 TO 1979:4)    34 OBSERVATIONS
DEPENDENT VARIABLE:    UKBOTHEUF

          COEFFICIENT    STD. ERROR     T-STAT     INDEPENDENT VAR.

            407.230         23.62        17.24     CONSTANT

 1)                                                PDL(UKBPRC%WPIUKB\1,
                                                      2,6,BOTH)
  \1      -0.0450741      0.01614                        .
  \2      -0.0751235      0.02689                        .
  \3      -0.0901482      0.03227                        .
  \4      -0.0901482      0.03227                        .
  \5      -0.0751235      0.02689                        .
  \6      -0.0450741      0.01614                        .
  SUM      -0.420692       0.1506       -2.793           .
  AVG        2.50000          0.0

R-BAR SQUARED:   0.1709
DURBIN-WATSON STATISTIC:   0.0801
STANDARD ERROR OF THE REGRESSION:  4.476   NORMALIZED:  0.01311
```

DEFINITIONS OF VARIABLES

UKBOTHEUF = UKBOTHCON/JQINDUKB

UKBOTHCON = Consumption of Unbleached Other Board

JQINDUKB = FLDUKBRAT & JQINDP208 + (1-FLDUKBRAT)*JQINDMN

FLDUKBRAT = Ratio of Unbleached Foldingboard to Unbleached Other Board

JQIND208 = Industrial production index - beverages

JQINDMN = Industrial production index - nondurable manufacturing

UKBPRC%WPIUKB = UKBOTHPRCNS/WPIUKB

UKBOTHPRCNS = Weighted average* of price of Bleached Foldingboard and Unbleached Linerboard

WPIUKB = Weighted average* of wholesale price indexes - food and industrial commodities, s.a.

*Weights are FLDUKBRAT and (1-FLDUKBRAT), respectively

# ALL OTHER BOARD

## 2. Gypsum Board

```
ANNUAL(1966 TO 1978)   13 OBSERVATIONS
DEPENDENT VARIABLE:   GYPRCBEUF

        COEFFICIENT   STD. ERROR    T-STAT    INDEPENDENT VAR.

          41.9097        4.404       9.516    CONSTANT

 1)      -0.232677     0.04182      -5.564    ICR72

 2)                                           PDL(BPBRELPICR,1,
  \0     -6.68330        1.783         .          2,FAR)
  \1     -3.34190       0.8914         .
  SUM    -10.0257        2.674   .  -3.749
  AVG    0.333333          0.0

R-BAR SQUARED:  0.7111
DURBIN-WATSON STATISTIC:  2.6170
STANDARD ERROR OF THE REGRESSION:  1.076   NORMALIZED:  0.05433
```

DEFINITIONS OF VARIABLES

GYPRCBEUF = GYPRCBDPNS/ICR72

GYPRCBDPNS = Shipments of Gypsum Board

ICR72 = Investment in residential structures in 1972 $

BPBRELPICR = WPI092/PICR

WPI092 = Wholesale price index - Construction Paper and Board

PICR = Price deflator - residential investment

## ALL OTHER BOARD

### 3. Tube, Can and Drum

```
ANNUAL(1970 TO 1978)   9 OBSERVATIONS
DEPENDENT VARIABLE: . TCDRCBEUF

          COEFFICIENT    STD. ERROR    T-STAT    INDEPENDENT VAR.

            964.863        371.5        2.597    CONSTANT

 1)                                              PDL(TCDOILRPR,1,
  \0       -166.662        192.5                    3,FAR)
  \1       -111.108        128.3          .
  \2       -55.5540        64.16          .
  SUM      -333.324        385.0          .
  AVG      0.666667          0.0     -0.8659

R-BAR SQUARED:  -0.0323
DURBIN-WATSON STATISTIC:  0.6993
STANDARD ERROR OF THE REGRESSION:  38.02   NORMALIZED:  0.05910
```

DEFINITIONS OF VARIABLES

TCDRCBEUF = TCDRCBDPNS/JQIND

TCDRCBDPNS = Shipments of Tube, Can and Drum Board

JQIND = Industrial production index - total

TCDOILRPR = WPI09150751NS/WPI

WPI09150751NS = Wholesale price index - motor oil cans

WPI = Wholesale price index - total

## ALL OTHER BOARD

### 4. Recycled Board - Balance of All Other

```
ANNUAL(1970 TO 1978)    9 OBSERVATIONS
DEPENDENT VARIABLE:    RCBBAOEUF

          COEFFICIENT    STD. ERROR     T-STAT     INDEPENDENT VAR

            4861.19         290.0       16.76      CONSTANT

 1)            .                                   PDL(RCBBAORPR,
  \0       -498.146         134.4         .           1,2,FAR)
  \1       -249.073         67.20         .
  SUM      -747.219         201.6      -3.706
  AVG      0.333333           0.0

 2)        -960.673         79.84      -12.03      LOG(TIME)

R-BAR SQUARED:   0.9610
DURBIN-WATSON STATISTIC:   3.2834
STANDARD ERROR OF THE REGRESSION:   21.32    NORMALIZED:   0.02434
```

DEFINITIONS OF VARIABLES

RCBBAOEUF = RCBBAODPNS/JQIND

RCBBAODPNS = Shipments of Recycled Board - Balance of All Other

JQIND = Industrial production index - total

RCBBAORPR = WPI09140332NS/WPI

WPI09140332NS = Wholesale price index - chipboard

WPI = Wholesale price index - total

# DISSOLVING PULP

```
QUARTERLY(1972:1 TO 1980:2)    34 OBSERVATIONS
DEPENDENT VARIABLE:    EUFPLPDIS@US

         COEFFICIENT    STD. ERROR     T-STAT    INDEPENDENT VARIABLE

            267.177        8.413        31.76    CONSTANT

 1)                                              PDL(RPRPLPDIS@US\1,2,8,
                                                  BOTH)
  \1      -0.0326859    0.002474                           .
  \2      -0.0572004    0.004330                           .
  \3      -0.0735433    0.005567                           .
  \4      -0.0817148    0.006186                           .
  \5      -0.0817148    0.006186                           .
  \6      -0.0735433    0.005567                           .
  \7      -0.0572004    0.004330                           .
  \8      -0.0326859    0.002474                           .
  SUM      -0.490289     0.03711       -13.21
  AVG       3.50000          0.0

R-BAR SQUARED:   0.8402
DURBIN-WATSON STATISTIC:   0.0391
STANDARD ERROR OF THE REGRESSION:   10.38   NORMALIZED:   0.06546
```

DEFINITIONS OF VARIABLES

EUFPLPDIS@US = APCPLPDIS@US/JQINDDIS

APCPLPDIS@US = Apparent consumption of Dissolving Pulp in the U.S.

JQINDDIS = .4*JQIND23 + .2*JQIND301 + .4*JQINDMN

JQIND23 = Industrial production index - apparel

JQIND301 = Industrial production index - tires

JQIND301 = Industrial production index - nondurable manufactured goods

RPRPLPDIS@US = PPLPBSSS@CN/PGNP

PPLPBSSS@CN = Price of Canadian Bleached Kraft Softwood Pulp ($/metric ton)

PGNP = GNP deflator (1972 = 1.00)

# Appendix 2-C

## Method for Annualizing Quarterly Demand Curves

Given the specification of a quarterly demand curve, the problem is to find an equivalent annual demand curve which shows the total demand of four successive quarters as a function of an annual average price. The key assumption for the formula presented here is that the quarterly prices and demand indicators in the quarterly demand curve can be replaced by the corresponding annual average values. This is not too stringent a simplification because, the price terms in DRI's demand equations are usually seasonally adjusted and always deflated by an appropriate price index. Futhermore, a numerical example comparing the results of using a quarterly demand curve and its annualized counterpart given below shows very small differences.

Because the general formula for annualization is cumbersome to derive, we instead present a simple example to show how the procedure works. Ignoring the exogenous demand components, inventory change, exports and imports (these can simply be summed over four quarters to get annual exogenous demand), we have the quarterly demand equation

$$D_t = EUF_t \times IND_t \tag{2C-1}$$

where D = demand, EUF = end-use factor, and IND = demand indicator. (See Section 2, equations (2-5) to (2-7).) Assume the following correspondence between quarters and years:

year T contains quarters t; t-1, t-2, t-3;

year T-1 contains quarters t-4, ···, t-7.

We can then obtain annual demand

$$D_T \equiv \sum_{i=o}^{3} D_{t-i} = \sum_{i=o}^{3} EUF_{t-i} \times IND_{t-i} \tag{2C-2}$$

If we assume that the quarterly values of $IND_t$ are equal, we can replace them with the annual average $IND_T$ (=$IND_t$, ..., $IND_{t-3}$). Substituting into equation (2C-2) yields

$$D_T = IND_T \sum_{i=o}^{3} EUF_{t-i} \qquad (2C-3)$$

An annual end-use factor can be defined as

$$EUF_T \equiv \sum_{i=o}^{3} EUF_{t-i} \qquad (2C-4)$$

The problem is to derive an expression for $EUF_T$ in terms of average annual rather than quarterly prices. It can then be substituted into equation (2C-3) to yield the annualized demand equation.

Consider the quarterly end-use factor equation

$$EUF_t = L(P_t) = \alpha_1 P_{t-1} + \alpha_2 P_{t-2} \qquad (2C-5)$$

where $P_t$ is quarterly price, L() is the lag operator*, and $\alpha_1$ and $\alpha_2$ are lag coefficients. Price is arbitrarily assumed to have lagged effects over two quarters. (The method shown here applies to any length lag.) Note that, as is the case with DRI's quarterly demand equations, price in the current quarter is not assumed to affect demand. Substituting (2C-5) into (2C-4) yields:

$$EUF_T = \alpha_1 P_{t-1} + (\alpha_1 + \alpha_2)P_{t-2} + (\alpha_1 + \alpha_2)P_{t-3}$$

$$+ (\alpha_1 + \alpha_2)P_{t-4} + \alpha_2 P_{t-5}. \qquad (2C-6)$$

---

*This simple form is adopted for expositional convenience. $P_t$ could represent any variable, e.g., $PQ_t$, $X_t$, etc. The lag operator L() is just a shorthand way of expressing the relationship in equation (2C-5). If $EUF_t$ is an additive function of more than one variable, i.e.,

$$EUF_t = \sum_{j=1}^{m} L_j (P_{jt}),$$

the annualization procedure can be applied to each $L_j(\ )$ term separately. The resulting terms on the right-hand side, of e.g. equation (2C-9), are then summed to give the expression

$$EUF_T = \sum_{j=1}^{m} L_j^* (P_{jT}).$$

Assume that quarterly prices within a year are constant, i.e. equal to the annual average price:

$$P_T = P_t = \ldots = P_{t-3}; \tag{2C-7}$$

$$P_{T-1} = P_{t-4} = \ldots = P_{t-7} \tag{2C-8}$$

Substituting equations (2C-7) and (2C-8) into (2C-6) and combining terms yields:

$$\begin{aligned} EUF_T &= (3\alpha_1 + 2\alpha_2)P_T + (\alpha_1 + 2\alpha_2)P_{T-1} \\ &\equiv L^*(P_T) \end{aligned} \tag{2C-9}$$

which is our annualized form. Note that although the quarterly end-use factor is a function only of lagged prices, the annual end-use factor is a function of current price as well. Substituting (2C-9) and (2C-4) into (2C-3) yields the annual demand equation.

Using annual average prices and demand indicators should not introduce a significant bias into the demand estimate as long as the quarterly end-use factors and demand indicators are not highly correlated.

As a test of this procedure, quarterly demands for the period 1987:1 - 85:4 for Uncoated Groundwood were generated using DRI's forecast of quarterly price terms and demand indicators together with the quarterly end-use factor equation. (See Appendix 2-B for the specification of the equation.) These demands were summed over each year to yield annual demands. Next, the annualized end-use factor equation derived by the above method together with the annual averages of the price and demand indicator series were used to predict another set of annual demands over the same period. These two demand series are presented in Table 2C-1. The deviations are less than two percent and usually no greater than one percent. Moreover, the differences are not all positive or all negative, suggesting that the procedure does not impart a significant bias.

In practice, when the annualized demand curves are calculated, they are adjusted with an add factor, so that DRI's forecast is reproduced exactly. This adjustment merely assures that the annualized demand curve would reproduce DRI's forecast of annual output given annual

Table 2C-1. Comparison of Results of Quarterly and Annual Demand Curves for Uncoated Groundwood

| Year | (1) Sum of Quarterly Demands ($10^3$ tons/yr) | (2) Annualized Demand ($10^3$ tons/yr) | (3) Percent Difference* |
|---|---|---|---|
| 1978 | 1131 | 1135 | 0.4 |
| 1979 | 1196 | 1185 | -1.0 |
| 1980 | 1223 | 1241 | 1.5 |
| 1981 | 1237 | 1232 | -0.4 |
| 1982 | 1296 | 1284 | -1.0 |
| 1983 | 1377 | 1392 | 1.0 |
| 1984 | 1550 | 1550 | 0.0 |
| 1985 | 1675 | 1670 | -0.03 |

---

$*\frac{(2) - (1)}{(1)} \times 100$

Source: DRI, Meta Systems estimates

averages of DRI's projected prices and other exogenous variables. This does not mean that the base forecast from the demand/supply analysis will be identical to DRI's because the supply side is modelled differently by DRI than by Meta Systems and because our capacity forecasts may differ as well. The effect of this adjustment on changes in price and output due to treatment costs is negligible.

Because of the long lag structures in DRI's demand equations, lagged annual prices often have a strong effect on current demand. In some cases, the strong lagged effect tends to impart a cyclical demand response to any shock to the system; i.e., a high price in one period shifts the demand curve to the left in the next period, implying a lower price, which then causes the demand curve to shift to the right in the next period. Such cycling is not observed in the historical data. One of the reasons for describing the demand/supply impacts in terms of three-year averages is to smooth this cycling.

# Appendix 2-D

## Derivation of Capital Recovery Factor

The capital recovery factor can be expressed analytically as follows. Let:

$R$ = annual revenue
$C$ = annual variable costs: labor, materials, energy, etc.
$I$ = investment cost
$\pi$ = capital recovery factor = $(R-C)/I$
$d$ = depreciation rate
$t$ = tax rate
$K_f$ = weighted cost of capital (after-tax)
$N$ = investment lifetime in years
$A(K_f,N)$ = annuity whose present value equals 1, given discount rate $K_f$ and lifetime $N$.

Given revenues and direct costs, average cost of capital, tax rates, depreciation rates, and investment lifetime, the problem is to find that gross return per dollar of invested capital which allows the firm to just cover its costs of capital, depreciation, and taxes and maintain the value of the firm. Equation (2D-1) expresses the relationship that must hold for the firm to break even on its invested capital, I. In other words, the present discounted value of the net income flow (using the average cost of capital as the discount factor) just equals the cost of the firm's initial investment:

$$\sum_{j=1}^{N} \frac{(R-C) - t(R-C) + tdI}{(1 + K_f)^j} = I \qquad (2D\text{-}1)$$

The numerator of the left-hand side of equation (2D-1) shows net profits plus the tax subsidy on depreciation. Note that the tax subsidy on interest payments is not included because it is already taken into account by using the after-tax cost of debt in the average cost of capital. Dividing equation (2D-1) by I and substituting $\pi$ for $(R-C)/I$ gives:

$$\sum_{j=1}^{N} \frac{\pi - t\pi + td}{(1 + K_f)^j} = 1 \qquad (2D\text{-}2)$$

Note that if the numerator is assumed constant (i.e., constant R-C, depreciation and tax rates) over all periods, it represents the annuity whose present value is 1, given discount rate $K_f$ and lifetime, N, i.e., $A(K_f,N)$. We can then "solve" equation (2D-2) for $\pi$ using the tables for "Annuity whose Present Value is 1." Then $\pi$ will be the "capital recovery factor," expressed as a percentage of initial investment, which must be added to direct operating costs to ensure the project return equals its cost of capital. The result is given below:

$$\pi - t\pi + td = A(K_f,N)$$

$$\pi = \frac{A(K_f,N) - td}{1 - t} \qquad (2D\text{-}3)$$

# Appendix 2-E

## Product Sector Supply Curves

This appendix gives the econometric estimates of the product sector supply curves used in the demand/supply analysis. Data used to estimate the curves were taken from the 308 Survey and the Technical Contractor's estimates of pollution control costs. The methodology used to construct the curves was described in Section 2. Only the equations for the base case supply curves are given here. Those for the various treatment options are quite similar, since total annual pollution control costs are almost always less than 10 percent of variable production costs.

Three basic functional forms were used:

linear: $c = a + bq;$

inhomogeneous exponential: $c = a_1 + a_2 \cdot e^{bq};$

inhomogeneous power: $c = a_1 + a_2 q^b$

where $c$ = variable costs per ton, $q$ = cumulative production, and $a_1$ and $a_2$ are coefficients to be estimated. The linear form was used for Glassine and Greaseproof and Special Industrial Papers and the power form for Uncoated Freesheet. For the exponential form, two different techniques were used. In some cases, $a_1$ was constrained to be zero, thus reducing the equation to the homogeneous form. This allowed the equation to be estimated by ordinary least squares after taking logarithms of both sides. In these cases, the coefficients and t-statistics are given for $\ln(a_2)$ and b. When $a_1$ was not constrained, a nonlinear technique was used to estimate the equation. In this case, coefficients and t-statistics are given for $a_1$, $a_2$ and b. Note that here the t-statistics are asymptotic approximations.

Table 2E-1 shows the coefficient estimates, t-statistics, adjusted R-squared ($\bar{R}^2$), degrees of freedom (D.F.) and F value of the regression. In general the fits are good. The adjusted R-squared of the log versions tend to be lower because of the log transformation. In some of the inhomogeneous estimates, the t-statistics are low although the R-squared is high because of high correlation of the coefficient estimates. This does not affect the use of the supply curve equation for predictions.

Table 2E-1: Estimates of Product Sector Supply Curves

| Name | Coefficient | T-statistic | $\bar{R}^2$ | D.F. | F Value |
|---|---|---|---|---|---|
| Dissolving Pulp | | | | | |
| $\ln(a_2)$ | 5.398 | 187.6 | .947 | 7 | 125.9 |
| b | .3703 | 11.22 | | | |
| Unbleached Kraft Paper | | | | | |
| $\ln(a_2)$ | 4.717 | 46.54 | .666 | 43 | 85.8 |
| b | .3227 | 9.26 | | | |
| Bleached Kraft Paper | | | | | |
| $\ln(a_2)$ | 5.202 | 71.80 | .825 | 39 | 184.4 |
| b | 1.309 | 13.58 | | | |
| Glassine and Greaseproof | | | | | |
| a | 525.4 | 9.05 | .669 | 8 | 16.2 |
| b | 1858.1 | 4.02 | | | |
| Tissue | | | | | |
| $a_1$ | 28.45 | 0.65 | .997 | 85 | 12,535 |
| $a_2$ | 251.4 | 6.76 | | | |
| b | .3616 | 12.62 | | | |
| Special Industrial Papers | | | | | |
| $a_1$ | 215.3 | 3.26 | .990 | 57 | 2,821 |
| $a_2$ | 108.3 | 3.14 | | | |
| b | 4.407 | 9.08 | | | |

Table 2E-1: (cont.)

| Name | Coefficient | T-statistics | $\bar{R}^2$ | D.F. | F Value |
|---|---|---|---|---|---|
| Newsprint | | | | | |
| $a_1$ | 133.1 | 4.73 | .998 | 21 | 5,239 |
| $a_2$ | 34.74 | 1.50 | | | |
| b | .3736 | 2.93 | | | |
| Coated Printing | | | | | |
| $a_1$ | 269.9 | 19.89 | .998 | 42 | 11,340 |
| $a_2$ | 27.61 | 4.04 | | | |
| b | .6017 | 11.89 | | | |
| Uncoated Freesheet | | | | | |
| $a_1$ | 114.9 | 4.97 | .976 | 96 | 1,991 |
| $a_2$ | 142.3 | 17.48 | | | |
| b | .7120 | | | | |
| Uncoated Groundwood | | | | | |
| $a_1$ | 195.2 | 6.40 | .985 | 19 | 631 |
| $a_2$ | 9.650 | 1.04 | | | |
| b | 2.982 | 3.85 | | | |
| Thin Papers | | | | | |
| $a_1$ | -59.09 | -.180 | .979 | 15 | 399 |
| $a_2$ | 321.1 | 1.21 | | | |
| b | 3.862 | 2.34 | | | |
| Solid Bleached Bristols | | | | | |
| $\ln(a_2)$ | 5.212 | 32.13 | .657 | 20 | 38.2 |
| b | 1.532 | 6.18 | | | |

Table 2E-1: (cont.)

| Name | Coefficient | T-statistic | $\bar{R}^2$ | D.F. | F Value |
|---|---|---|---|---|---|
| Cotton Fibre | | | | | |
| $\ln(a_2)$ | 487.1 | 13.23 | .910 | 21 | 212.5 |
| b | 9,044 | 14.58 | | | |
| Unbleached Linerboard | | | | | |
| $a_1$ | 84.92 | 5.35 | .999 | 45 | 15,671 |
| $a_2$ | 37.72 | 2.77 | | | |
| b | .09790 | 4.95 | | | |
| Unbleached Foldingboard | | | | | |
| $\ln(a_2)$ | 4.931 | 18.12 | .508 | 2 | 2.06 |
| b | 1.407 | 1.44 | | | |
| Bleached Linerboard | | | | | |
| $\ln(a_2)$ | 5.278 | 65.16 | .659 | 4 | 7.73 |
| b | 3.822 | 2.78 | | | |
| Bleached Foldingboard | | | | | |
| $a_1$ | 65.07 | 0.66 | .998 | 12 | 2,871 |
| $a_2$ | 120.2 | 1.32 | | | |
| b | .4653 | 2.02 | | | |
| Solid Bleached Board | | | | | |
| $a_1$ | 177.1 | 10.31 | .996 | 16 | 1,989 |
| $a_2$ | 16.02 | 1.58 | | | |
| b | 1.602 | 4.42 | | | |

Table 2E-1: (cont.)

| Name | Coefficient | T-statistic | $\bar{R}^2$ | D.F. | F Value |
|---|---|---|---|---|---|
| Semi-Chemical Corrugating Medium | | | | | |
| $a_1$ | 62.84 | 2.73 | .998 | 34 | 8,671 |
| $a_2$ | 40.24 | 1.97 | | | |
| b | .2706 | 3.35 | | | |
| Recycled Linerboard | | | | | |
| $a_1$ | 54.43 | 1.14 | .991 | 21 | 1,156 |
| $a_2$ | 49.33 | 1.24 | | | |
| b | 1.876 | 2.31 | | | |
| Recycled Corrugating Medium | | | | | |
| $\ln(a_2)$ | 4.540 | 71.91 | .750 | 20 | 60.0 |
| b | .7691 | 7.75 | | | |
| Recycled Foldingboard | | | | | |
| $a_1$ | 171.4 | 46.67 | .998 | 54 | 11,633 |
| $a_2$ | 1.554 | 2.06 | | | |
| b | 1.563 | 9.08 | | | |
| Construction Paper and Board | | | | | |
| $a_1$ | 134.0 | 53.39 | .992 | 88 | 5,652 |
| $a_2$ | .01665 | 2.17 | | | |
| b | 3.580 | 21.15 | | | |
| All Other Board | | | | | |
| $\ln(a_2)$ | 3.901 | 28.97 | .692 | 57 | 128.0 |
| b | 1.279 | 11.31 | | | |

Source: 308 Survey

## Section 3

## Structure of the Pulp, Paper and Paperboard Industry

### Introduction

This description of the economic and financial structure of the Pulp, Paper, and Paperboard Industry is organized on the basis of major product sectors. These sectors constitute aggregations of the important groups of intermediate and end products which the industry manufactures, such as: Market Pulp, Unbleached Kraft Linerboard, and Uncoated Freesheet Paper. Products are used as the basis for dividing the industry into segments since they are the focus of the economic activity affecting the industry. It is these economic considerations which will determine how the industry responds to increased effluent control costs. The product sector divisions used are based on the grade descriptions defined by the American Paper Institute. This section describes the types of firms and mills that form the industry in terms of characteristics such as size, age, and location. In addition, the relationship between product sectors and industry subcategories (industry categories used for the purpose of defining effluent limitations and assessing the costs of implementing control technologies) is explained. The nature of capacity expansion, the role of research and development (R&D), and technological change are also discussed.

### Product Sectors

The characteristics of mills making up the various product sectors of the Pulp, Paper and Paperboard Industry depend upon the particular economic details of each sector. Volume II presents detailed profiles of individual product sectors. This discussion provides a summary and comparison of these product sector characteristics. For paper producers, mills are categorized on the basis of size or capacity; for paperboard producers, mills are categorized on the basis of type of furnish as well as size; and for pulp producers, mills are categorized on the basis of product markets. This classification is useful because many other firm and mill characteristics such as degree of integration, concentration, planned expansion, regional distribution, and productivity appear related to these categories.* Using data from the individual product sector descriptions compiled in Volume II, the product sector categories are discussed below, in terms of both firm and mill characteristics.

---

*The "all other paper" and "all other paperboard" sectors are mixed categories, and therefore are left out of this classification discussion.

## Paper Producers

The most useful categorization for highlighting the characteristics of paper producing firms and mills is volume of production. This correlates well with the markets and types of products produced.

Small Volume Paper Product Category (Table 3-1). This category includes firms and mills producing low volume and/or specialty paper products which are individually under three percent of all paper production. These are special purpose or high quality paper products characterized by a large value-added in production and relatively low volume of production. Products include Thin, Glassine and Greaseproof, Cotton Fibre, and Special Industrial papers. Together these product sectors account for six percent of all paper capacity.

The product sectors included in this category are generally concentrated, that is, a small number of firms control a large percentage of the production capacity. The firms have a lower level of vertical integration relative to firms producing larger volume paper products. They tend to be privately owned and, with the exception of Special Industrial Paper producers, tend to be one-mill firms. Several product sectors in the group (Glassine and Greaseproof, Cotton Fibre, Thin Papers) suffer from substitution pressure from plastics or other papers.

The paper products included in this category are typically manufactured in small (50 to 100 tons per day), urban-centered, old mills. Roughly 85 percent of these mills are located in the Northeast and North Central regions of the country. Relative to mills producing larger volume products, more of these mills are indirect discharges. Generally, productivity growth in these categories is low, machinery is older and expansion plans are minimal. Due to these factors, small volume sectors have less economic strength than the larger volume paper products sectors. However, because many of the products manufactured in these categories cater to specialized markets, economic health is correspondingly varied.

Medium Volume Paper Product Category (Table 3-2). Mills and firms in this category produce medium volume products which individually account for three to four percent of all paper production. Included are miscellaneous intermediate volume paper products such as Solid Bleached Bristols, Uncoated Groundwood, and Bleached Kraft papers. About 11 percent of total paper capacity is included in these sectors.

TABLE 3-1. CHARACTERISTICS OF SMALL VOLUME PAPER PRODUCERS

| Characteristic | Product Sectors | | | |
|---|---|---|---|---|
| | Glassine and Greaseproof | Cotton Fiber | Special Industrial | Thin Papers |
| Product Sector Concentration | highly concentrated | moderately concentrated | not concentrated | concentrated |
| Level of Vertical Integration | moderate | low | low | high |
| Level of Horizontal Integration | moderate | low | high | low |
| Ownership of Largest Firms | half public; half private | most private; few public | most private; few public | most private; few public |
| Economic/Technological Trends | severe competition from plastics | competition from chemical wood-pulp papers | specialized applications, few substitutes | competition from carbonless copy-paper |
| Number of Firms/Mills | 8/10 | 19/23 | 40/63 | 18/21 |
| Median Mill Size (tons/day) | 105 | 52 | 58 | 96 |
| Primary Location | Northeast, North Central | Northeast, North Central | Northeast | Northeast, North Central |
| Number of Indirect Dischargers | 1 | 16 | 26 | 5 |
| Planned Expansion | small | small | moderate | moderate |
| Technological "Age" of Mills | old | old | old | old |
| Productivity Growth | low | low | low | low |

Source: Based on data in Volume II and Appendix 7-A.

TABLE 3-2. CHARACTERISTICS OF MEDIUM VOLUME PAPER PRODUCERS

| Characteristics | Solid Bleached Bristol | Uncoated Groundwood | Bleached Kraft Paper |
|---|---|---|---|
| Product Sector Concentration | concentrated | concentrated | concentrated |
| Level of Vertical Integration | high | high | high |
| Level of Horizontal Integration | moderate | low to moderate | moderate |
| Ownership of Largest Firms | most public; few private | half public; half private | almost all public |
| Economic/Technological Trends | declining due to changes in computer and office technology | recent gains; quality innovations | heavy penetration by plastics |
| Number of Firms/ Mills | 18/22 | 17/22 | 30/41 |
| Median Mill Size (tons/day) | 553 | 468 | 420 |
| Primary Location | Northeast,<br>Southeast,<br>North Central | Northeast,<br>North Central | Northeast,<br>Southeast,<br>North Central |
| Number of Indirect Dischargers | 7 | 4 | 9 |
| Planned Expansion | none | large | small |
| Technological "Age" of Mills | intermediate | intermediate | new |
| Productivity Growth | low | low | small |

Source: Based on data in Volume II and Appendix 7-A.

These are concentrated product sectors with the top five and eight firms controlling roughly 60 and 80 percent, respectively, of production capacity. The level of vertical integration of the firms from raw material to converted product is high and the level of horizontal integration is generally moderate. Most firms in these sectors control only one mill and more are publicly owned than those in the small volume paper sectors. Economic trends in these sectors are mixed.

Mills in this category are of substantially larger size (about 500 tons per day), than those producing small volume paper products. They tend to have somewhat newer capital stock and more widespread regional distribution than the smaller, specialty mills. However, their productivity growth has been lower and their expansion plans are generally more modest than the large volume paper producers.

Large Volume Paper Product Category (Table 3-3). The large volume paper category includes product sectors which each account for 13 to 25 percent of all paper production and includes the following papers: Uncoated Freesheet, Coated Printing, Unbleached Kraft, Newsprint and Tissue Papers. Together, this category includes about 82 percent of all paper production capacity.

The product sectors making up the large volume category tend to be somewhat less concentrated than their smaller volume counterparts. Firms in these sectors have a high level of vertical integration and a low to moderate level of horizontal integration. The largest firms are primarily publicly owned and the incidence of multi-mill firms is higher than in the lower volume subcategories. Economic and technological trends in these sectors can be characterized as very positive due to increasing demand and resistance to competition.

Products in this category are made by generally large scale, new mills. In contrast to the smaller volume categories, productivity growth is high and large expansions are planned for these mills.

### Paperboard Producers

Paperboard producers can also be classified according to volume of production as was done for paper producers. However, a more meaningful categorization is based upon the raw material used in production, either recycled material or virgin wood products. Within these two groups, size distinctions can then be made.

TABLE 3-3. CHARACTERISTICS OF LARGE VOLUME PAPER PRODUCERS

| Characteristics | Uncoated Freesheet | Coated Printing | Unbleached Kraft | Newsprint | Tissue |
|---|---|---|---|---|---|
| Product Sector Concentration | not concentrated | not concentrated | moderately/ concentrated | concentrated | concentrated |
| Level of Vertical Integration | high | high | high | high | high |
| Level of Horizontal Integration | low to moderate | low to moderate | low to moderate | moderate | moderate |
| Ownership of Largest Firms | almost all public | almost all public | almost all public | most public; few private | most public; few private |
| Economic/Technological Trends | diverse markets and increasing demand | some plastics penetration; trends follow advertising boom | resisted plastics competition | quality innovations; competitive with other media | consumer tissue: recession-proof, non-price marketing incentives; industrial tissue: follows level of employment |
| Number of Firms/Mills | 53/103 | 30/45 | 29/45 | 16/24 | 42/90 |
| Median Mill Size (tons/day) | 271 | 517 | 886 | 836 | 137 |
| Primary Location | Northeast, North Central | Northeast, North Central | Southeast | Southeast, Northwest | Northeast, North Central |
| Number of Indirect Dischargers | 34 | 11 | 7 | 3 | 27 |
| Planned Expansion | large | large | moderate | large | moderate |
| Technological "Age" of Mills | generally new | intermediate | new | new | new |
| Productivity Growth | high | high | recently low | high | high |

Source: Based on data in Volume II and Appendix 7-A.

Recycled Material-Based Paperboard Category (Table 3-4). This category includes products ranging from one percent to ten percent of total paperboard production. The processes used to produce these products employ large amounts of secondary fiber in their furnish. Included in this category are Recycled Corrugating Medium, Recycled Linerboard, and Recycled Foldingboard. Molded Pulp Products and Construction Paper and Board have also been classified in this category since a high percentage of mills in each sector use processes based on wastepaper. The large volume sectors within this category together account for 20 percent of total paperboard capacity, the medium volume group accounts for seven percent and the total category accounts for 28 percent.

The most important distinctions between the recycled material-based paperboard producers and virgin wood-based paperboard producers occur in mill characteristics rather than firm characteristics. However, a couple of comparisons can be made for firms. In contrast to firms in the wood-based category, recycled-based firms tend to have a higher degree of private ownership. Also, their economic trends tend to be less promising since many product markets are mature and there is some encroachment by plastics. The Construction Paper and Board sector does not fit this pattern as its products are designed for specialized markets.

Several characteristics of firms in this category vary according to size. For instance, the small volume sector is highly concentrated, the medium volume sector is moderately concentrated and the large volume sectors are generally less concentrated. The level of vertical integration is generally high in this category mainly because most wastepaper users prepare their own wastepaper pulp. Horizontal integration for these firms is low except for the Molded Pulp firms. Both the small volume and large volume firms tend to be multi-mill while the medium volume ones are one-mill firms.

One of the most obvious distinctions between the recycled and virgin fiber paperboard categories is the size of the mills. The recycled mills are small in size, less than 200 tons per day, in contrast to the virgin wood mills which are very large, near 1,000 tons per day or higher. These mills tend also to be older and are located primarily in the Northeast and North Central parts of the country, near their fiber supplies. Since they are located near urban areas, many more of them are indirect discharges. Productivity growth has been slower than for virgin fiber mills.

Wood-Based Paperboard Category (Table 3-5). Product sectors in this category each have production levels that range from less than one percent of total paperboard production to 41 percent. The products classified here use primarily virgin wood pulp for their furnish and include

TABLE 3-4. CHARACTERISTICS OF RECYCLED MATERIAL-BASED PAPERBOARD PRODUCERS

| | Small Volume | Medium Volume | | Large Volume | |
|---|---|---|---|---|---|
| Characteristics | Molded Pulp Products | Recycled Corrugating Medium | Recycled Linerboard | Recycled Foldingboard | Construction Paper and Board |
| Product Sector Concentration | highly concentrated | moderately concentrated | moderately concentrated | not concentrated | moderately concentrated |
| Level of Vertical Integration | high | moderate | high | high | high |
| Level of Horizontal Integration | moderate to high | low | low | low | low to moderate |
| Ownership of Largest Firms | most public; few private | half public; half private | half public; half private | half public; half private | almost all private |
| Economic/Technological Trends | plastics competition but new market development | mature market | mature market | plastics encroachment; disadvantages compared to virgin foldingboard | remodelling uses mitigate severe demand fluctuations; few substitutes |
| Number of Firms/ Mills | 5/14 | 20/27 | 20/25 | 48/75 | 44/100 |
| Median Mill Size (tons/day) | 69 | 189 | 140 | 160 | 101 |
| Primary Location | Northeast | North Central | Northeast<br>North Central | Northeast<br>North Central | Northeast<br>Southeast, North Central, West and Southwest |
| Number of Indirect Discharges | 8 | 27 | 13 | 75 | 54 |
| Planned Expansion | not available | moderate | large | small | small |
| Technological "Age" of Mills | not available | intermediate | old | intermediate to old | varies with products |
| Productivity Growth | not available | moderate | low | low | moderate |

Source: Based on data in Volume II and Appendix 7-A

TABLE 3-5. CHARACTERISTICS OF WOOD-BASED PAPERBOARD PRODUCERS

| Characteristics | Small Volume | Medium Volume | | Large Volume | |
|---|---|---|---|---|---|
| | Bleached Kraft Linerboard | Bleached Foldingboard | Solid Bleached Board | Unbleached Kraft Linerboard | Semi-Chemical Corrugating Medium |
| Product Sector Concentration | highly concentrated | concentrated | concentrated | not concentrated | not concentrated |
| Level of Vertical Integration | high | high | high | high | high |
| Level of Horizontal Integration | low | low to moderate | moderate | low | moderate |
| Ownership of Largest Firms | most public; few private | almost all public | almost all public | almost all public | almost all public |
| Economic/Technological Trends | higher quality product that follows unbleached linerboard trends | some plastics penetration; strong medical packaging demands | heavy plastics competition | resisted competition | few substitutes |
| Number of Firms/ Mills | 6/6 | 13/17 | 17/19 | 29/48 | 29/37 |
| Median Mill Size (tons/day) | 1,613 | 1,264 | 1,400 | 1,255 | 858 |
| Primary Location | Southeast | Southeast | Southeast | Southeast | Southeast |
| Number of Indirect Discharges | 0 | 2 | 1 | 3 | 3 |
| Planned Expansion | moderate | moderate | small | large | large |
| Technological "Age" of Mills | intermediate to new | intermediate | intermediate | new | new |
| Productivity Growth | moderate | moderate | moderate | high | high |

Source: Based on data in Volume II and Appendix 7-A.

Bleached Kraft Linerboard, Bleached Foldingboard, Solid Bleached Board, Unbleached Kraft Linerboard, and Semi-Chemical Corrugating Medium. These tend to be low value-added products. The large volume sectors within this category together account for 54 percent of total paperboard capacity, the medium volume class accounts for 11 percent, and the whole category accounts for about 66 percent.

As explained above, firm characteristics in the paperboard categories vary primarily by size rather than by furnish type. The larger volume firms are much less concentrated than the smaller volume ones. There are also more multi-mill firms in the large volume sectors. The smallest volume firms include more which are privately owned than the larger volume classes. However, in general, there is a much greater degree of public ownership of the wood-based firms than of the recycled-based firms. The level of vertical integration in this category is high as many firms control their own timber operations. The level of horizontal integration is low to moderate. While there has been plastics competition for some products included in this category, such as for Solid Bleached Boards, most of these sectors have a strong economic outlook.

As mentioned above, the mills in this category tend to be much larger than mills making recycled paperboard products and they are larger than most paper producers as well. They primarily are located in rural areas of the Southeast and thus very few are indirect discharges. The ages of these mills tend to be younger, their productivity growth higher and their expansion plans larger than those for recycled mills. Together, these factors indicate that the economic health of these sectors is very good.

### Pulp Producers (Table 3-6).

Only two pulp product sectors have been considered in this study: Dissolving Pulp and all other Market Pulp. Dissolving Pulp has been classified separately, as it is a highly specialized product with uses that are not connected to the rest of the paper industry. All other pulps, such as Bleached Kraft Pulp, are used in the production of paper or paperboard either directly by the firm that produces them or through purchase by another firm. These last are Market Pulps.

The pulp product sectors have different concentration levels. Dissolving Pulp is highly concentrated, with only a few producers of this product. There are many producers of other types of Market Pulp, none of whom control very large amounts of the production capability.

## TABLE 3-6. CHARACTERISTICS OF PULP PRODUCERS

| Characteristics | Dissolving Pulp | Other Market Pulp |
|---|---|---|
| Product Sector Concentration | highly concentrated | not concentrated |
| Level of Vertical Integration | high | high |
| Level of Horizontal Integration | high | moderate |
| Ownership of Largest Firms | almost all public | almost all public |
| Economic/Technological Trends | decreasing demand | substitution of sulfate for sulfite process; sensitive to world market conditions |
| Number of Firms/ Mills | 6/9 | 47/76 |
| Median Mill Size (tons/day) | 638 | 886 |
| Primary Location | Southeast, Northwest | Southeast |
| Number of Indirect Dischargers | 0 | 7 |
| Planned Expansion | none | not available |
| Technological "Age" of Mill | intermediate | depends on process |
| Productivity Growth | high | recently low |

Source: Based on data in Volume II and Appendix.

Both sectors have a high degree of public ownership of firms and have many firms with a high level of vertical integration. Horizontal integration is common for Dissolving Pulp firms and less so for other Market Pulp firms. Economic trends for these sectors differ: Dissolving Pulp firms are experiencing decreasing demand and other Market Pulp producing firms' demand fluctuates with the world market. There is a higher percentage of multi-mill firms in the other Market Pulp sector than in the Dissolving Pulp sector.

Mills in both pulp sectors are large (600 to 900 tons per day), located primarily in the Southeast and Northwest, and nearly all are direct dischargers. Productivity growth in the Dissolving Pulp sector is high and for other Market Pulp mills was high but has more recently been low. Dissolving Pulp mills are of an intermediate age and have no expansion plans. For other Market Pulp mills, the age depends on the process used and expansion plan data is not available.

## General Trends

The characteristics of firms and mills making up the various product sectors of the Pulp, Paper and Paperboard Industry -- regional distribution, size, age -- depend upon the particular economic details of the sector involved, as discussed above. However, several generalizations about these characteristics can be made and are presented below.

### Integration from Pulp to Paper Making

The degree to which a mill's production process is integrated from pulp to papermaking varies from sector to sector. For the purpose of this economic analysis, mills were classified into three categories: integrated, nonintegrated, and secondary fiber. Integrated mills are those which contain both pulp and papermaking facilities. Nonintegrated mills are those which purchase pulp and then use it to produce paper or paperboard. Secondary fiber mills are those that primarily use wastepaper as a furnish and thus are considered integrated as they normally produce their own wastepaper pulp.

Table 3-7 ranks paper and paperboard product sectors by degree of integration. In general, the degree of integration is dependent on the value of the end product. Mills producing low price-per-unit products are usually integrated (e.g., Newsprint, Uncoated Groundwood, Unbleached Linerboard), while specialized, high value products (e.g., Special Industrial) frequently are nonintegrated. The level of integration is also related to the location of the mill. Integrated mills are more often located in rural areas, while nonintegrated mills operate nearer urban areas. Secondary fiber mills also operate near urban areas.

TABLE 3-7. PRODUCT SECTORS AND DEGREE OF INTEGRATION

| | Product Sectors | Percentage of Mills in Product Sector Classified as Nonintegrated |
|---|---|---|
| | Paper | |
| Integrated | Newsprint | 0.0% |
| | Uncoated Groundwood | 13.6 |
| | Unbleached Kraft Paper | 24.4 |
| | Coated Printing | 33.3 |
| | Bleached Kraft Paper | 34.1 |
| | Tissue | 35.6 |
| | Solid Bleached Bristols | 36.4 |
| | Uncoated Freesheets | 44.7 |
| | Thin Papers | 57.1 |
| | Cotton Fiber | 65.2 |
| ↓ | Special Industrial | 66.7 |
| Nonintegrated | Glassine and Greaseproof | 80.0 |
| | Paperboard | |
| Integrated | Unbleached Kraft Linerboard | 0.0% |
| | Bleached Kraft Linerboard | 0.0 |
| | Semi-Chemical Corrugating | 0.0 |
| | Recycled Linerboard | 0.0 |
| | Recycled Corrugating | 0.0 |
| | Molded Pulp Products | 0.0 |
| | Solid Bleached Board | 0.0 |
| | Recycled Foldingboard | 1.3 |
| | Construction Paper and Board | 4.0 |
| ↓ | Bleached Foldingboard | 5.9 |

Source: 308 Survey

Low value products are usually standardized, and thus do not need the same contact with their markets that the manufacturers of specialized products need. In addition, access to raw materials tends to be very important in the production of low value items. For secondary fiber mills, (e.g., Tissue, Recycled Boards, Construction Paper and Board mills) the best sources of wastepaper are urban areas.

## Regional Distribution

The regional distribution of mills and capacity is shown in Tables 3-8a and 3-8b. While a majority of mills (61 percent) are located in the Northeastern and North Central Regions of the country, most production capacity is located in the Southeast. The Northeastern and North Central mills tend to be in nonintegrated or secondary fiber sectors which produce very small portions of total paper, paperboard, and market pulp. The combined effect of the impact of integration and the regional distribution of mills can be seen in Tables 3-9 and 3-10. Several product sectors are heavily concentrated in the Northeast and North Central regions, including Cotton Fibre, Special Industrial, Glassine and Greaseproof Papers, and Coated Printing. In the Southeast are found heavy concentrations of Bleached and Unbleached Kraft Linerboard, Solid Bleached Board, and Bleached Foldingboard.

This regional distribution also holds for capacity. The Introduction to Volume II presents a ranking of product sectors by total capacity. Based on capacity the four paper sectors most highly concentrated in the Northeast and North Central regions -- Glassine and Greaseproof Paper, Special Industrial Paper, Thin Paper, and Cotton Fibre Paper -- together constitute less than three percent of total paper, paperboard, and market pulp production. In addition, Recycled Corrugating Medium, Recycled Foldingboard, All Other Paperboard, Recycled Linerboard, and Molded Pulp Products, the five paperboard product sectors most highly concentrated in the Northeast and North Central Regions, constitute less than twelve percent of total capacity.

In contrast, the Southeast is characterized by integrated mills producing the larger volume products. Three of the largest product sectors, Unbleached Kraft Linerboard, Other Market Pulp, and Semi-Chemical Corrugating Medium, which together have almost 35 percent of total U.S. paper, paperboard, and market pulp capacity, are heavily represented in the Southeast. There is a strong regional trend toward production by large, integrated mills producing low value products in the Southeast and small, secondary fiber and nonintegrated mills producing higher value added products in the Northeast and North Central regions.

## TABLE 3-8. REGIONAL DISTRIBUTION OF MILLS AND CAPACITY

### TABLE 3-8A. REGIONAL DISTRIBUTION OF MILLS

| Region* | Number of Mills | Percent |
|---|---|---|
| Northeast | 215 | 34.0 |
| Southeast | 144 | 22.7 |
| North Central | 171 | 27.0 |
| Northwest | 41 | 6.5 |
| West & Southwest | 62 | 9.8 |
| Total | 633 | 100.0 |

### TABLE 3-8B. REGIONAL DISTRIBUTION OF CAPACITY
(Thousands of short tons/day)

| Region* | Pulp** |  | Paper |  | Paperboard |  |
|---|---|---|---|---|---|---|
|  | Capacity | Percent | Capacity | Percent | Capacity | Percent |
| Northeast | 25.83 | 13.36 | 23.39 | 26.73 | 11.30 | 10.83 |
| Southeast | 94.80 | 49.05 | 29.74 | 33.98 | 55.77 | 52.17 |
| North Central | 27.62 | 14.29 | 19.80 | 22.62 | 16.20 | 15.27 |
| Northwest | 23.96 | 12.40 | 9.21 | 10.52 | 9.06 | 8.59 |
| West & Southwest | 21.06 | 10.90 | 5.38 | 6.15 | 13.13 | 13.14 |
| Total | 193.27 | 100.00 | 87.52 | 100.00 | 105.44 | 100.00 |

Source: 308 Survey

*Northeast includes: Connecticut, Delaware, Maine, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, Puerto Rico;

Southeast includes: Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Maryland, Mississippi, North Carolina, South Carolina, Tennessee, Virginia, West Virginia;

North Central includes: Illinois, Indiana, Iowa, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, Wisconsin;

Northwest includes: Alaska, Idaho, Oregon, Washington;

West & Southwest includes: Arizona, California, Colorado, Kansas, Montana, Nevada, New Mexico, Oklahoma, Texas, Utah, Wyoming.

Hawaii -- not in the analysis, but classed in West & Southwest.

**Includes capacity in Deink and Wastepaper (42.08 thousand short tons/day).

TABLE 3-9. PRODUCTION IN NORTHEAST AND NORTH CENTRAL REGIONS

| Paper Sectors | Percentage of Mills Located in Northeast or North Central | Paperboard Sectors | Percentage of Mills Located in Northeast or North Central |
|---|---|---|---|
| Cotton Fiber | 95.7% | Recycled Corrugating Medium | 70.4% |
| Other Paper | 90.9 | Recycled Foldingboard | 69.3 |
| Special Industrial | 82.5 | All Other Paperboard* | 63.2 |
| Glassine and Greaseproof | 80.0 | Recycled Linerboard | 60.0 |
| Coated Printing | 80.0 | Molded Pulp Products | 57.2 |
| Thin Papers | 76.2 | Construction Paper and Board | 55.0 |
| Uncoated Freesheet | 75.7 | Semi-Chemical Corrugating Medium | 27.0 |
| Uncoated Groundwood | 72.7 | Bleached Foldingboard | 11.8 |
| Tissue | 67.8 | Solid Bleached Board | 5.3 |
| Bleached Kraft | 51.2 | Unbleached Kraft Linerboard | 0.0 |
| Solid Bleached Bristols | 50.0 | Bleached Kraft Linerboard | 0.0 |
| Unbleached Kraft | 33.3 | Pulp Sectors | |
| Newsprint | 25.0 | Market Pulp | 19.7% |
| | | Dissolving Pulp | 0.0 |

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*Includes Unbleached Kraft Foldingboard

Source: 308 Survey

TABLE 3-10. PRODUCTION IN SOUTHEAST REGION

| Paper Sectors | Percentage of Mills Located in Southeast | Paperboard Sectors | Percentage of Mills Located in Southeast |
|---|---|---|---|
| Unbleached Kraft Paper | 46.7% | Unbleached Kraft Linerboard | 70.8% |
| Solid Bleached Bristols | 31.8 | Solid Bleached Board | 68.4 |
| Bleached Kraft | 29.3 | Bleached Kraft Linerboard | 66.7 |
| Newsprint | 29.2 | Bleached Foldingboard | 64.7 |
| Thin Paper | 14.3 | Semi-Chemical Corrugating Medium | 48.7 |
| Coated Printing | 13.3 | All Other Paperboard* | 23.5 |
| Tissue | 13.3 | Construction Paper and Board | 22.0 |
| Uncoated Freesheets | 12.6 | Molded Pulp Products | 21.4 |
| Special Industrial | 11.1 | Recycled Foldingboard | 17.3 |
| Glassine and Greaseproof | 10.0 | Recycled Linerboard | 16.0 |
| Uncoated Groundwood | 9.1 | Recycled Corrugating Medium | 7.4 |
| All Other Paper | 4.6 | Pulp Sectors | |
| Cotton Fiber | 4.4 | Market Pulp | 46.1% |
| | | Dissolving Pulp | 44.4 |

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*Includes Unbleached Kraft Foldingboard

Source: 308 Survey

## Capacity

Most of the investment in new capacity by the Paper and Paperboard Industry is in the Southeast region of the United States, and almost entirely by large integrated firms. The one exception is the investment in nonintegrated mills in the Northeast. Table 3-11 presents a regional breakdown of recent capital expenditures. Investment in the Southeast was over twice as great as investment in any other region. Due to recent investment patterns, the average and median mill ages in product sectors characterized by integrated mills are decreasing, while mean and median ages of product sectors characterized by nonintegrated or secondary fiber mills are increasing.

Over the past several years one of the most noticeable characteristics of the industry has been the amount of new capacity generated at existing mills. Rebuilds and improvements of machines in place and the introduction of new machines into existing mills will account for over 80 percent of capacity expansion in the next year or two. At some point, scale economies can no longer be realized by increasing mill size due to the costs of transporting wood to the mill sites. However, the high cost of building new mills and the costs (or time delays) of meeting environmental and other regulations for new sites frequently make them unattractive investments. Whatever the case may be, recent data suggest that most new capacity will come from existing mills. Table 3-12 shows projected capacity changes by sector for the industry.

For paper, the product sectors with the largest projected growth rates in capacity are: Newsprint, Coated Printing, Uncoated Freesheet, and Uncoated Groundwood. Smaller increases in capacity are found in Unbleached Kraft, Tissue, Special Industrial, and Thin Paper. The paperboard product sectors which are expected to grow most rapidly are: Unbleached Linerboard, Recycled Linerboard, and Semi-Chemical Corrugating Medium. Smaller increases in capacity are expected in Recycled Corrugating Medium, Bleached Linerboard, and Bleached Foldingboard.

## International Capacity

The United States is the world's largest producer and consumer of forest products. Roughly 35 percent of 1978 total world paper, paperboard, and pulp production came from U.S. mills, while 1979 U.S. consumption (64.3 million metric tons) far outpaces second-ranked Japan

TABLE 3-11. RECENT CAPITAL EXPENDITURES BY REGION

| Region | Capital Expenditures During Five-Year Period in mid-1970s ($\$ \times 10^6$) |
|---|---|
| Northeast | 1,749.4 |
| Southeast | 3,611.2 |
| North Central | 1,611.1 |
| Northwest | 1,698.7 |
| West and Southwest | 828.2 |

Source: 308 Survey

Table 3-12: Projected Capacity Changes, by Product Sector ($10^3$ short tons)*

| Sector | 1979 Capacity | 1985 Capacity | Average Annual Growth Rate |
|---|---|---|---|
| Pulp | | | |
| Dissolving Pulp | 1,536 | 1,537 | 0 |
| Paper | | | |
| Unbleached Kraft | 4,261 | 4,620 | 1.3% |
| Bleached Kraft | 1,051 | 1,112 | 0.9% |
| Glassine and Greaseproof | 220 | 233 | 1.0% |
| Tissue | 4,885 | 5,474 | 1.9% |
| Special Industrial | 928 | 1,029 | 1.7% |
| Newsprint | 4,109 | 6,416 | 7.4% |
| Coated Printing | 4,741 | 6,348 | 4.9% |
| Uncoated Freesheet | 8,095 | 9,901 | 3.4% |
| Uncoated Groundwood | 1,537 | 2,022 | 4.6% |
| Thin Papers | 412 | 465 | 2.0% |
| Solid Bleached Bristols | 1,146 | 1,148 | 0 |
| Cotton Fiber | 129 | 131 | 0.3% |
| Paperboard | | | |
| Unbleached Linerboard | 14,087 | 17,587 | 3.7% |
| Bleached Linerboard | 133 | 152 | 2.2% |
| Bleached Foldingboard | 2,080 | 2,320 | 1.8% |
| Solid Bleached Board | 2,105 | 2,201 | 0.7% |
| Semi-Chemical Corrugating | 4,851 | 5,899 | 3.3% |
| Recycled Foldingboard | 3,009 | 3,178 | 0.9% |
| Recycled Linerboard | 354 | 433 | 3.4% |

Table 3-12 (cont.)

| Sector | 1979 Capacity | 1985 Capacity | Average Annual Growth Rate |
|---|---|---|---|
| Paperboard (cont.) | | | |
| Recycled Corrugating | 1,700 | 1,997 | 2.7% |
| Construction Paper & Board | 7,067 | 7,501 | 1.0% |
| All Other Paperboard, including Unbleached Foldingboard | 5,055 | 5,443 | 1.2% |

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*For a more detailed presentation, and sources, see Appendix 7-A.

(17.5 million metric tons), and third-ranked West Germany (9.5 million tons). Stated differently, the 637 pounds of pulp, paper, and paperboard consumed in 1979 by each American was far higher than Canada's 474 or Sweden's 470 pounds per capita. No other country consumed over 400 pounds of forest products per capita last year.

Though the United States clearly dominates world production and consumption of forest products, its rate of production expansion has not kept pace with other parts of the world. The U.S. 1977-1978 production increase was 2.7 percent, compared to increases of 3.5 percent in Europe and 7.0 percent in Asia. This is consistent with the long-term (1960-1978) expansion trend in which Asia/Australia's annual rate of production expansion was 11.9 percent; Latin America, 8.1 percent; Europe. 4.3 percent; and North America, 3.5 percent. These percent increases, however, ignore the base of which expansion grows. Thus the North American paper and paperboard tonnage increase from 1960 to 1978 was 32.5 million metric tons, compared to Europe's 30.5 million, Asia's 24.3 million, and Latin America's 4.7 million.

The faster growth rates in Europe, Asia, and Latin America have reduced the North American proportion of world pulp, paper, and paperboard, if not North America's pre-eminence in the industry. In 1960, North America accounted for 53 percent of world paper and paperboard output and 54 percent of pulp output, while in 1978 these proportions had fallen to 43 percent and 49 percent respectively. The 1979 U.S. contribution to North American pulp production was roughly 70 percent and roughly 81 percent to North American paper and board production. Developing countries currently produce less than one-quarter of the world's paper and board and less than one-fifth of the world's pulp. Although both rates represent increases for developing countries since 1960, North American world dominance will continue for a long time. As an example, two recently announced new U.S. mills (Weyerhauser in Mississippi and International Paper in Louisiana) will add almost as much capacity to these companies as Africa's total 1978 production.

## Trends in Technology

Research and development has never been a major activity for the pulp and paper industry. Compared with research-oriented basic industries like organic chemicals, it spends little on research and development. On the average, it allocates about 0.7 percent of its sales revenues to this area. In most years, organic chemical firms spend at least five times that much as a percentage of their sales.

For pulp and paper firms, funds made available for research are divided betweeen process development and product research. In recent years, research on process has focused as much on air and water pollution control as it has on process changes designed to increase productivity. As the Development Document has shown, however, process changes designed to reduce pollution may also reduce costs.* Two areas gaining more attention are fiber recovery and energy savings. In 1978, approximately 53 percent of fibrous raw material was derived from recovered materials: 22 percent from wastepaper (a slight increase), 30 percent from forest and manufacturing residues, and 1 percent from other fibers.** At the same time, hog fuel use increased from 5.5 million tons in 1972 to 12 million tons in 1978.+ Clearly, a conflict between using residual materials as a fiber source or for energy generation is developing.

One sector where the results of research in product development are most noticeable is tissue with the development of fluff pulps and air layering. Another is uncoated groundwood where the development of the supercalendering process has improved product characteristics to the extent that penetration into higher quality markets has been possible.++

A variety of technological innovations are either being introduced or more widely adopted in the industry. Mechanized harvesting, whole tree chipping, residue derived fuels, thermo-mechanical pulping, displacement bleaching and washing, and computerized process control are now firmly entrenched. Oxygen pulping and bleaching, pretreatment of wood chips with hydrogen sulfide in the sulphate process, and polysulfide pulping with sulphate are also commercially used. Some years away are high-consistency forming and dry forming. It would appear that most innovations which are likely to be commercially attractive in the near future will be those which reduce fiber requirements (or conversely, increase yield), effluent loads, or energy needs.

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*Preliminary Data Base for Review of BATEA Effluent Limitations Guideleines, NSPS and Pretreatment Standards for the Pulp, Paper, and Paperboard Point Source Category, prepared for U.S. EPA by E.C. Jordan, Portland, Maine, June 1979

**Pulp and Paper, May 1979.

+Pulp and Paper, May 1979.

++Recent estimates of demand show a much faster growth in the demand for these improved uncoated groundwood papers. Between 1979 and 1983, growth of newsprint is estimated to increase 8.6%, while demand for improved grades are estimated to increase 19%. Paper Trade Journal, October 30, 1980, p. 24.

## The Relationship Between Product Sectors and Industry Subcategories

In addition to the division into product sectors for the purpose of economic impact analysis, the industry has been divided into units called subcategories. These are formed by grouping mills which employ similar production and process techniques. This was necessary so that EPA could develop uniform national effluent limitations and standards which would affect similar mills in a similar fashion in terms of modifications required and costs incurred. The relationship between the product sectors and the industry subcategories is illustrated in Tables 3-13 and 3-14. Each table is organized as an array in which the rows are product sectors and the columns are subcategories. In Table 3-13 the cell entries are the percentages of that subcategory's production which go into the production of the various product sectors. The percentages are obtained by dividing a subcategory's product sector production by total subcategory production. For example, there are eighteen mills in the subcategory Tissue from Wastepaper and they produce approximately 8,283,000 tons of paper per year. Nearly all of this production (92 percent) goes into the manufacturing of Tissue Paper and only about 5 percent goes into the manufacturing of Special Industrial Paper. Table 3-14 contains the percentage of a product sector's production which is manufactured by each subcategory. To calculate these cell entries a sector's total production is divided into individual subcategories' sector productions. While most subcategories contribute to several sectors, the majority of a subcategory's production (over 70 percent) goes to no more than two product sectors, and a majority of a product sector's production (again, over 60 percent) is contributed by two or fewer subcaterories.

Several other generalizations can be made from these tables. Almost all nonintegrated production capacity is in the paper, rather than the paperboard, sector. The only exceptions are Construction Paper and Board and All Other Paperboard product sectors. Nonintegrated subcategories account for less than 4 percent of each of these product sector's capacity, even though these two product sectors account for over 23 percent of Nonintegrated Paperboard's capacity. Each secondary fiber subcategory has much of its capacity concentrated in a particular product sector (see Table 3-15). Integrated subcategories production is primarily in low value per unit output product sectors, as mentioned earlier. No integrated subcategory has more than 5 percent of its capacity in any of the following high value-per-unit output product sectors:

Bleached Kraft Papers
Glassine and Greaseproof Papers
Special Industrial Paper
Thin Papers
Cotton Fibre Paper
Bleached Linerboard

TABLE 3-13. Percentage of Subcategory Production in Each Product Sector

| | Dissolving Kraft | Market Bleached Kraft | BCT Bleached Kraft | Fine Bleached Kraft & Soda | Unbleached Kraft (Linerboard) | Unbleached Kraft (Bag) | Semi-Chemical | Unbleached Kraft & Semi-Chemical | Dissolving Sulfite Pulp | Papergrade Sulfite | Groundwood - Thermo-Mechanical | Groundwood - Course, Molded, Newsprint | Groundwood - Fine Papers | Miscellaneous Integrated | Deink (Fine Papers) | Deink (Newsprint) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PRODUCT SECTOR: | | | | | | | | | | | | | | | | |
| Dissolving Pulp | * | | | | | | | | 79 | | | | | | | |
| Market Pulp | * | 89 | 16 | 9 | * | * | * | | 21 | * | | | | 12 | | |
| Unbl. Kraft | | | | | | 34 | | 18 | | | | | | 8 | | |
| Bl. Kraft | | | | * | | * | | | | | | | | 4 | | |
| Glassine | | | | | | | | | | * | | | | * | | |
| Tissue | | * | * | * | | * | * | | | 44 | | | | 4 | | |
| Special Industrial | | | | * | | | | | | * | | | | 1 | | |
| Newsprint | | | | | | | | | | | * | * | | 16 | | * |
| Coated Printing | | | | 37 | | | | | | | | | 79 | 6 | | |
| Uncoated Freesheet | | | | 42 | | | * | | | 38 | | * | * | 9 | * | |
| Uncoated Groundwood | | | | * | | | | | | | * | * | * | 4 | * | |
| Thin Papers | | | | * | | * | | | | | | | * | | | |
| Solid Bl. Bristols | | | * | * | | | * | | | * | | | | 2 | | |
| Cotton Fibre | | | | | | | | | | | | | | | | |
| All Other Paper | | | * | * | | | | | | * | | | | | | |
| Unbl. Linerboard | | | | | * | 51 | | 56 | | | | | | 17 | | |
| Bl. Linerboard | | * | * | | | | | | | | | | | | | |
| Bl. Foldingboard | | * | 42 | | | | | | | | | | | 5 | | |
| Solid Bl. Board | | * | 21 | | | | | | | | | | | 6 | | |
| Semi-Chem. Corrugating | | | | | | | 87 | 19 | | * | | | | 4 | | |
| Recycled Linerboard | | | | | | | | | | | | | | | | |
| Recycled Corrugating | | | | | | | * | | | | | | | * | | |
| Recycled Foldingboard | | | | | | | * | | | * | | | | * | | |
| Construction Paper & Bd. | | | | | | | | | | | | | | * | | |
| Molded Pulp | | | | | | | | | | | | * | | * | | |
| All Other Paperboard | | | | | | * | | 7 | | * | | | | | | |
| Total Production ($10^3$ short tons/ year) | * | 2,124 | 2,338 | 5,087 | 5,378 | 3,261 | 2,931 | 5,208 | 931 | 2,072 | * | * | 1,437 | 19,258 | 361 | * |
| Number of Mills | * | 10 | 8 | 21 | 17 | 11 | 20 | 10 | 6 | 16 | * | * | 9 | 81 | 5 | * |

*Publication would disclose information about an aggregate of four or fewer mills.

Note: Row and column sums may not equal 100% due to data suppression.

TABLE 3-13. Percentage of Subcategory Production in Each Product Sector (continued)

| | Deink (Tissue) | Tissue from Wastepaper | Paperboard from Wastepaper | Wastepaper Molded | Builders' Paper & Roofing Felt | Miscellaneous Secondary Fiber | Nonintegrated Fine Papers | Nonintegrated Tissue Papers | Nonintegrated Lightweight | Nonintegrated Filter & Nonwoven | Nonintegrated Lightweight-Elec. Allow. | Nonintegrated Paperboard | Miscellaneous Nonintegrated | Total Production (10³ short tons/yr) | Number of Mills |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PRODUCT SECTOR: | | | | | | | | | | | | | | | |
| Dissolving Pulp | | | | | | | | | | | | | | 1,361 | 9 |
| Market Pulp | | | | | | * | | * | | | | | | 5,057 | 76 |
| Unbl. Kraft | * | * | * | | | | * | | | | | * | 2 | 3,704 | 44 |
| Bl. Kraft | * | * | * | | | | * | * | * | | | * | 5 | 1,093 | 40 |
| Glassine | | | | | | | * | | | | | | 12 | 220 | 10 |
| Tissue | 95 | 92 | * | | | 7 | * | 98 | * | | | | * | 4,116 | 89 |
| Special Industrial | | * | * | | | * | * | * | | 95 | * | * | 23 | 602 | 63 |
| Newsprint | | | | | | | | | | | | | | 3,944 | 24 |
| Coated Printing | | | | | | * | 25 | | * | | | * | * | 4,546 | 45 |
| Uncoated Freesheet | | | | | | 28 | 55 | | * | * | | * | 13 | 6,442 | 103 |
| Uncoated Groundwood | | | | | | * | * | | | | | | | 1,179 | 22 |
| Thin Papers | | * | | | | * | * | | 63 | | * | | * | 396 | 21 |
| Solid Bl. Bristols | | | | | | * | * | | | | | | * | 860 | 22 |
| Cotton Fibre | | | | | | | 2 | | | * | | | * | 120 | 23 |
| All Other Paper | | | * | | | * | * | | | * | | * | * | 213 | 22 |
| Unbl. Linerboard | | | | | | | | | | | | | | 13,104 | 48 |
| Bl. Linerboard | | | | | | | | | | | | | | 95 | 6 |
| Bl. Foldingboard | | | * | | | | * | | | | | | | 1,918 | 17 |
| Solid Bl. Board | | | * | | | | | | | | | | | 1,621 | 19 |
| Semi-Chem. Corrugating | | | | | | | | | | | | | | 4,222 | 37 |
| Recycled Linerboard | | | 9 | | | * | | | | | | | | 759 | 25 |
| Recycled Corrugating | | | 15 | | | * | | | | | | | | 1,160 | 27 |
| Recycled Foldingboard | | | 40 | | | * | * | | | | | | | 2,894 | 75 |
| Construction Paper & Bd. | | | 12 | | 100 | * | | | | | | * | * | 2,841 | 99 |
| Molded Pulp | | | | * | | | | | | | | | | 279 | 14 |
| All Other Paperboard | | | 22 | * | | * | | | | | | * | * | 2,080 | 68 |
| Total Production (10³ short tons/year) | 666 | 8,283 | 6,507 | 145 | 1,585 | 1,158 | 2,089 | 1,234 | 286 | 62 | * | 128 | 906 | | |
| Number of Mills | 13 | 18 | 150 | 8 | 61 | 16 | 41 | 26 | 11 | 14 | * | 11 | 35 | | |

*Publication would disclose information about an aggregate of four or fewer mills.

Note: Row and column sums may not equal 100% due to data suppression.

TABLE 3-14. Percentage of Total Product Sector Production Manufactured by Subcategory

|  | Dissolving Kraft | Market Bleached Kraft | BCT Bleached Kraft | Fine Bleached Kraft & Soda | Unbleached Kraft (Linerboard) | Unbleached Kraft (Bag) | Semi-Chemical | Unbleached Kraft & Semi-Chemical | Dissolving Sulfite Pulp | Papergrade Sulfite | Groundwood - Thermo-Mechanical | Groundwood - Course, Molded, Newsprint | Groundwood - Fine Papers | Miscellaneous Integrated | Deink (Fine Papers) | Deink (Newsprint) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PRODUCT SECTOR: |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Dissolving Pulp | * |  |  |  |  |  |  |  | * |  |  |  |  |  |  |  |
| Market Pulp | * | 20 | 8 | 8 | * | * | * |  | 4 | * |  |  |  | 45 |  |  |
| Unbl. Kraft |  |  |  |  |  | 30 |  | 26 |  |  |  |  |  | 42 |  |  |
| Bl. Kraft |  |  |  | * |  | * |  |  |  |  |  |  |  | 59 |  |  |
| Glassine |  |  |  |  |  |  |  |  |  | * |  |  |  | * |  |  |
| Tissue |  | * | * | * |  | * | * |  |  | 20 |  |  |  | 19 |  |  |
| Special Industrial |  |  |  | * |  | * |  |  |  | * |  |  |  | 15 |  |  |
| Newsprint |  |  |  |  |  |  |  |  |  |  | * | * |  | 75 |  | * |
| Coated Printing |  |  |  | 38 |  |  |  |  |  |  |  |  | 25 | 22 |  |  |
| Uncoated Freesheet |  |  |  | 31 |  |  | * |  |  | 11 |  | * | * | 26 | 5 |  |
| Uncoated Groundwood |  |  |  | * |  |  |  |  |  |  | * | * | * | 55 | * |  |
| Thin Papers |  |  |  | * |  | * |  |  |  |  |  |  | * | * |  |  |
| Solid Bl. Bristols |  |  | * | * |  |  | * |  |  | * |  |  |  | 35 |  |  |
| Cotton Fibre |  |  |  |  |  |  |  |  |  |  |  |  |  | 57 |  |  |
| All Other Paper |  |  | * | * |  |  |  |  |  | * |  |  |  | * |  |  |
| Unbl. Linerboard |  |  |  |  | 41 | 13 |  | 22 |  |  |  |  |  | 24 |  |  |
| Bl. Linerboard |  | * | * |  |  |  |  |  |  |  |  |  |  | * |  |  |
| Bl. Foldingboard |  | * | 53 |  |  |  |  |  |  |  |  |  |  | 47 |  |  |
| Solid Bl. Board |  | * | 32 |  |  |  |  |  |  |  |  |  |  | 65 |  |  |
| Semi-Chem. Corrugating |  |  |  |  |  |  | * | * |  | * |  |  |  | * |  |  |
| Recycled Linerboard |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Recycled Corrugating |  |  |  |  |  |  | * |  |  |  |  |  |  | * |  |  |
| Recycled Foldingboard |  |  |  |  |  |  | * |  |  | * |  |  |  | * |  |  |
| Construction Paper & Bd. |  |  |  |  |  |  |  |  |  |  |  |  |  | * |  |  |
| Molded Pulp |  |  |  |  |  |  |  |  |  |  |  | * |  | * |  |  |
| All Other Paperboard |  |  |  |  |  | * |  | 16 |  | * |  |  |  | * |  |  |
| Total Production ($10^3$ short tons/ year) | * | 2,124 | 2,338 | 5,087 | 5,378 | 3,261 | 2,931 | 5,208 | 931 | 2,072 | * | * | 1,437 | 19,258 | 361 | * |
| Number of Mills | * | 10 | 8 | 21 | 17 | 11 | 20 | 10 | 6 | 16 | * | * | 9 | 81 | 5 | * |

*Publication would disclose information about an aggregate of four or fewer mills.

Note: Row and column sums may not equal 100% due to data suppression.

## TABLE 3-14. Percentage of Total Product Sector Production Manufactured by Subcategory (continued)

| | Deink (Tissue) | Tissue from Wastepaper | Paperboard from Wastepaper | Wastepaper Molded | Builders' Paper & Roofing Felt | Miscellaneous Secondary Fiber | Nonintegrated Fine Papers | Nonintegrated Tissue Papers | Nonintegrated Lightweight | Nonintegrated Filter & Nonwoven | Nonintegrated Light-weight-Elec. Allow. | Nonintegrated Paperboard | Miscellaneous Nonintegrated | Total Production (10$^3$ short tons/yr) | Number of Mills |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PRODUCT SECTOR: | | | | | | | | | | | | | | | |
| Dissolving Pulp | | | | | | | | | | | | | | 1,361 | 9 |
| Market Pulp | | | | | | * | | * | | | | | | 5,057 | 76 |
| Unbl. Kraft | * | * | * | | | | * | | | | | * | | 3,704 | 44 |
| Bl. Kraft | * | * | * | | | | * | * | * | | | * | 4 | 1,093 | 40 |
| Glassine | | | | | | | * | | | | | | 50 | 220 | 10 |
| Tissue | 15 | 4 | * | | | 2 | * | 29 | | | | | * | 4,116 | 89 |
| Special Industrial | | * | * | | | * | * | * | | 10 | * | * | 34 | 602 | 63 |
| Newsprint | | | | | | | | | | | | | | 3,944 | 24 |
| Coated Printing | | | | | | * | 11 | | * | | | * | * | 4,546 | 45 |
| Uncoated Freesheet | | | | | | 5 | 18 | | * | * | | * | 2 | 6,442 | 103 |
| Uncoated Groundwood | | | | | | * | * | | | | | | | 1,179 | 22 |
| Thin Papers | | * | | | | * | * | | 45 | | * | | * | 396 | 21 |
| Solid Bl. Bristols | | | | | | * | * | | | | | | * | 860 | 22 |
| Cotton Fibre | | | | | | | 29 | | | * | | | * | 120 | 23 |
| All Other Paper | | | * | | | * | * | | | | | * | * | 213 | 22 |
| Unbl. Linerboard | | | | | | | | | | | | | | 13,104 | 48 |
| Bl. Linerboard | | | | | | | | | | | | | | 95 | 6 |
| Bl. Foldingboard | | | * | | | | * | | | | | | | 1,918 | 17 |
| Solid Bl. Board | | | * | | | | | | | | | | | 1,621 | 19 |
| Semi-Chem. Corrugating | | | | | | | | | | | | | | 4,222 | 37 |
| Recycled Linerboard | | | * | | | * | | | | | | | | 759 | 25 |
| Recycled Corrugating | | | 84 | | | * | | | | | | | | 1,160 | 27 |
| Recycled Foldingboard | | | 90 | | | * | * | | | | | | | 2,894 | 75 |
| Construction Paper & Bd. | | | 28 | | 56 | * | | | | | | * | | 2,841 | 99 |
| Molded Pulp | | | | 51 | | | | | | | | | | 279 | 14 |
| All Other Paperboard | | | 70 | * | | * | | | | | | * | * | 2,080 | 68 |
| Total Production (10$^3$ short tons/year) | 666 | 8,283 | 6,507 | 145 | 1,585 | 1,158 | 2,089 | 1,234 | 286 | 62 | * | 128 | 906 | | |
| Number of Mills | 13 | 18 | 150 | 8 | 61 | 16 | 41 | 26 | 11 | 14 | * | 11 | 35 | | |

*Publication would disclose information about an aggregate of four or fewer mills.

Note: Row and column sums may not equal 100% due to data suppression.

TABLE 3-15. IMPORTANT PRODUCT SECTORS FOR SECONDARY FIBER SUBCATEGORIES

| Production Subcategory | Primary Product Category | Percent Subcategory Capacity in Primary Product Category(s) |
|---|---|---|
| Deink (Fine Paper) | Uncoated Freesheet | 86% (Uncoated Freesheet) |
| Deink (Tissue) | Tissue | 95 (Tissue) |
| Tissue from Wastepaper | Tissue | 92 (Tissue) |
| Paperboard from Wastepaper | Recycled Board | 9 (Recycled Linerboard)<br>15 (Recycled Corrugating)<br>40 (Recycled Foldingboard) |
| Wastepaper Molded Products | Molded Pulp Products | 99 (Molded Pulp) |
| Builders' Paper and Roofing Felt | Construction Paper and Board | 100 (Construction) |

Source: 308 Survey

Given the extent to which sectors and subcategories are related, some of the comments made earlier about regional distribution of sector production and age of mills manufacturing the various products bear repeating in the context of subcategories (see Table 3-16). Sixteen of the twenty-seven subcategories have a majority (50 percent or more) of their mills in one region. Eight of those sixteen subcategories are integrated production processes, and four of these eight have a majority of mills in the Southeast. This is not surprising in light of our earlier analysis based on the 308 Survey which showed that the majority of integrated mills and integrated capacity is located in the Southeast. Seven subcategories have a majority of mills in the Northeast; of these, five are nonintegrated processes and two are secondary fiber.

Ranking subcategories by age shows that large, integrated mills tend to be newer than either secondary fiber or non-integrated mills (see Table 3-17). In part, this is because most recent investment has gone into integrated mills, making the average age of many integrated subcategories younger. However, there are exceptions to this generalization. Tissue from Wastepaper, the sixth youngest category, has only 0.3 percent of industry capacity and ranks twenty-fourth (out of 29 production categories) by capacity. Nonintegrated Fine Papers, the oldest subcategory, ranks tenth by capacity. Thus the age-size correlations which held for product sectors are not as important for subcategories.

Capacity can also be used to measure the degree to which a subcategory is dominated by a few mills, the degree of concentration for the subcategory. Table 3-18 presents the mean and total capacity for each subcategory. In addition, subcategories are ranked by the ratio of the capacity of the five largest mills to total capacity for the subcategory. As already stated, integrated mills (particularly Kraft mills) tend to be significantly larger than nonintegrated or secondary fiber mills. However high concentration ratios are not limited to the integrated subcategories. This is due in part to our definition of concentration. By using the top five mills, any subcategory with a small number of mills will have a high ratio. There are five subcategories with four or fewer mills. Excluding these five subcategories, the highest ratios are found in Deink (Fine Papers), Dissolving Sulfite, Nonintegrated Lightweight, Wastepaper Molded Products and Deink (Tissue). All these subcategories are relatively small. In terms of number of mills, these subcategories range from five to thirteen; and in terms of capacity they range from 563 tons per day to 2,674 tons per day. The three least concentrated subcategories, those with the smallest ratios, subcategories with very large numbers of mills. However, the next three have between eleven and twenty-one mills. This is because the mills within the subcategory are more nearly the same size, and therefore

TABLE 3-16. Concentration of Subcategories by Region

| Name | >50 Percent of Mills In Region |
|---|---|
| Unbleached Kraft (Linerboard) | Southeast (76.5%) |
| Unbleached Kraft (Bag) | Southeast (72.7%) |
| Unbleached Kraft and Semi-Chemical | Southeast (60.0%) |
| Market Bleached Kraft | Southeast (50.0%) |
| Dissolving Sulfite | Northwest (83.3%) |
| Deink (Fine Papers) | North Central (80.0%) |
| Groundwood Fine Papers | North Central (66.7%) |
| Papergrade Sulfite | North Central (62.5%) |
| Semi-Chemical | North Central (50.0%) |
| Nonintegrated Paperboard | Northeast (72.7%) |
| Nonintegrated Miscellaneous | Northeast (72.2%) |
| Nonintegrated Fine Papers | Northeast (56.1%) |
| Tissue from Wastepaper | Northeast (55.6%) |
| Nonintegrated Lightweight | Northeast (54.6%) |
| Deink (Tissue) | Northeast (53.9%) |
| Nonintegrated Filter and Nonwoven | Northeast (50.0%) |

Source: 308 Survey

TABLE 3-17: SUBCATEGORIES RANKED BY AGE OF MILL (Youngest to Oldest)

| Subcategory | Number of Mills | Mean Years From Initial Construction |
|---|---|---|
| Deink (Newsprint) | * | * |
| BCT Bleached Kraft | 7 | 21 |
| Market Bleached Kraft | 8 | 23 |
| Dissolving Kraft | * | * |
| Unbleached Kraft (Linerboard) | 30 | 29 |
| Tissue from Wastepaper | 17 | 33 |
| Unbleached Kraft & Semi-Chemical | 10 | 34 |
| Dissolving Sulfite | 6 | 36 |
| Wastepaper Molded Products | 12 | 37 |
| Builder's Paper and Roofing Felt | 58 | 40 |
| Groundwood - Coarse, Molded, News Papers | 6 | 41 |
| Paperboard from Wastepaper | 150 | 43 |
| Semi-Chemical | 11 | 53 |
| Nonintegrated Tissue Papers | 31 | 54 |
| Fine Bleached Kraft and Soda | 20 | 68 |
| Nonintegrated Lightweight | 14 | 70 |
| Papergrade Sulfite | 18 | 71 |
| Deink (Fine & Tissue) | 17 | 71 |
| Nonintegrated Filter and Woven | 15 | 74 |
| Groundwood - Fine Papers | 9 | 77 |
| Nonintegrated Paperboard | 14 | 80 |
| Nonintegrated Fine Papers | 37 | 87 |

Source: E.C. Jordan

## TABLE 3-18. CAPACITY BY SUBCATEGORY (TONS/DAY)

| Subcategory | Number Responding | Mean Capacity | Standard Deviation | Total Capacity | Ratio of Top 5 Mills to Total | Rank |
|---|---|---|---|---|---|---|
| Dissolving Kraft | * | * | * | * | * | * |
| Market Bleached Kraft | 10 | 724 | 422 | 7,240 | .68 | 15 |
| BCT Bleached Kraft | 8 | 1,121 | 427 | 8,971 | .77 | 11 |
| Fine Bleached Kraft & Soda | 21 | 682 | 294 | 14,329 | .38 | 26 |
| Unbl. Kraft (Linerboard) | 17 | 1,121 | 445 | 19,050 | .43 | 24 |
| Unbl. Kraft (Bag) | 11 | 907 | 650 | 9,982 | .74 | 13 |
| Semi-Chemical | 20 | 506 | 221 | 10,129 | .39 | 25 |
| Unbl. Kraft & Semi-Chemical | 10 | 1,678 | 702 | 16,776 | .67 | 16 |
| Dissolving Sulfite | 6 | 651 | 220 | 3,906 | .89 | 7 |
| Papergrade Sulfite | 16 | 391 | 223 | 6,258 | .52 | 21 |
| Groundwood-Thermo-Mechanical | * | * | * | * | * | * |
| Groundwood-Course, Molded, Newsprint | * | * | * | * | * | * |
| Groundwood-Fine Papers | 9 | 530 | 313 | 4,774 | .76 | 12 |
| Misc. Integrated Mills | 81 | 739 | 630 | 59,855 | .17 | 28 |
| Deink (Fine Papers) | 5 | 222 | 130 | 1,110 | 1.00 | 6 |
| Deink (Newsprint) | * | * | * | * | * | * |
| Deink (Tissue) | 13 | 206 | 354 | 2,674 | .79 | 10 |
| Tissue from Wastepaper | 18 | 40 | 36 | 725 | .58 | 18 |
| Paperboard from Wastepaper | 150 | 170 | 131 | 25,439 | .12 | 29 |
| Wastepaper Molded | 8 | 70 | 35 | 563 | .80 | 9 |
| Builders' Paper & Roofing Felt | 61 | 108 | 75 | 6,563 | .18 | 27 |
| Misc. Secondary Fiber Mills | 16 | 244 | 175 | 3,908 | .57 | 19 |
| Nonintegrated Fine Papers | 41 | 168 | 214 | 6,907 | .46 | 22 |
| Nonintegrated Tissue | 26 | 141 | 179 | 3,676 | .53 | 20 |
| Nonintegrated Lightweight | 11 | 93 | 84 | 1,018 | .82 | 8 |
| Nonintegrated Filter & Nonwoven | 14 | 21 | 15 | 288 | .66 | 17 |
| Nonintegrated Lightweight-Electrical Allowance | * | * | * | * | * | * |
| Nonintegrated Paperboard | 11 | 45 | 28 | 500 | .71 | 14 |
| Misc. Nonintegrated Mills | 35 | 96 | 105 | 3,365 | .44 | 23 |

Source: 308 Survey

no few mills dominate production. As with concentrated subcategories, the not concentrated subcategories are found in the integrated as well as the secondary and nonintegrated segments of the industry.

# Section 4

## Financial Profile

### Financial Overview

Following excellent years in 1978 and 1979, the Pulp, Paper and Paperboard Industry entered 1980 expecting a major downturn as the U.S. economy was finally driven into a recession by continued oil price increases, double-digit inflation, and the monetary strictness this inflation fostered. Companies which also produce lumber products were the first to feel the effects of the recession as housing starts dried up. This had the added effect of drastically reducing the supply of wood chips and residuals available for pulp production.

Economic growth turned negative in February of 1980, and by midsummer almost all paper and board grades were affected. As in the past, converted paperboard products were the first to feel the impact of the economic downturn. During the second quarter of 1980, demand was severely impacted, with total paper and board production dropping a seasonally adjusted annual rate of 24 percent. Production declined in all grades, except Newsprint, with Builder's Paper and Board and Recycled Paperboard being the hardest hit.

However, in comparison to the 1975 recession, this one has had a smaller impact on the Pulp, Paper and Paperboard Industry. Data Resources, Inc. predicts a drop of 3.5 percent in total U.S. paper and board production (including hardboard) in 1980.* This smaller impact is due in part to the Canadian newsprint mill strikes this summer, the strong export markets for pulp, linerboard and newsprint, and the lack of over-built consumer inventories. As a result, product prices have remained relatively stable, with minor weaknesses in linerboard and corrugated box prices.**

The future prospects for the Pulp, Paper and Paperboard Industry appear very good. Data Resources, Inc. expects paper and board production to begin growing again by the end of 1980 or early 1981. While growth in 1981 is expected to be only moderate, paper and board production is expected to grow at a faster rate between 1979 and 1985 than it did between 1973 and 1979. However, the future industry growth rate will probably be slightly lower than the general economic growth rate due to rising real paper prices, competition from substitutes (e.g., plastics and electronics), and a declining share of consumption expenditures with respect to total expenditures. These declines will be partially offset by growth in U.S. paper and board exports and technological advances in paper production.

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*Data Resources, Inc. "Monthly Comment Note," October 2, 1980, Papernotes #240.

**Clarence Brown, analyst with Lehman Brothers Kuhn Loeb, as reported in Paper Trade Journal, October 30, 1980.

Demand for Market Pulp also is expected to increase significantly, thereby improving the prospects for producers in this segment. Table 4-1 shows wood pulp production changes by grade from 1976 through the first half of 1980. Overall, total pulp production has been increasing, with decreases in Sulfite and large increases in Kraft. The world demand for market pulp is likely to increase over the next few years. In 1979, world production of paper and board was about 5.5 percent above 1978 levels, while world production of pulp increased only 4.7 percent. This was coupled with increased reliance on wastepaper. According to a recent survey, some 20 million annual tons of paper and board capacity are due to be added worldwide between 1980 and 1983, but only 13 million tons of pulp capacity.* Construction of market pulp mills has become very expensive. In addition, many market pulp producers are integrating downstream so that they can use their pulp to produce higher-value paper.

The financial performance of paper and allied industries during the last several years has been uniformly good, and in general much better than the early 1970s. (See Table 4-2.) Net sales have steadily increased since 1969, with sales in 1980 expected to be approximately 2.8 times those in 1969. Net profits declined between 1969 and 1972. Since 1972 they have steadily increased, with 1974 being an exceptionally profitable year. Profits in 1980 are expected to be slightly below those in 1979, but still higher than 1978 profits. Sales margin (the ratio of after-tax earnings to net sales) also declined between 1969 and 1972. Since then it has remained relatively stable, except for 1974 and 1979 which were particularly good years. Return on net worth has followed the pattern of sales margins. In spite of the recession in 1980, return on net worth for this year is expected to be only slightly below the 13.6 percent average for the previous seven years. Therefore, the industry as a whole can be characterized as strong, and in better shape than was true ten years ago.

One distinguishing characteristic of the Pulp and Paper Industry is the high level of capital investment required. Based on Department

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*Pulp and Paper International's "Projects Survey 1980-83," as reported in Pulp & Paper, August 1980.

TABLE 4-1. WOOD PULP PRODUCTION

| Grade | Production ($10^3$ tons) 1976 | Production ($10^3$ tons) 1979 | Total Percent Change (1976-79) | Percent Change (first half 1979 to first half 1980) |
|---|---|---|---|---|
| Dissolving and Special Alpha | 1,485 | 1,497 | 0.8% | 12.4% |
| Bleached Sulfite | 1,750 | 1,379 | -21.2 | 11.3 |
| Unbleached Sulfite | 419 | 396 | - 5.5 | - 0.7 |
| Bleached and Semi-Bleached Kraft | 15,773 | 18,061 | 14.5 | 7.8 |
| Unbleached Kraft | 17,826 | 19,930 | 11.8 | 2.2 |
| Semi-Chemical | 3,827 | 4,068 | 6.3 | 3.3 |
| Groundwood and TMP | 4,304 | 4,385 | 1.9 | 4.2 |
| Total, excluding Defibrated and Screening | 45,385 | 49,715 | 9.5 | 5.0 |
| Defibrated, Exploded and Screenings | 3,219* | 3,130 | - 2.8* | -28.2 |

Source: American Paper Institute, as reported in the Paper Trade Journal.

*1977 (1977-79).

TABLE 4-2. FINANCIAL PERFORMANCE OF PAPER AND ALLIED INDUSTRIES

| Year | Net Sales ($ billion) | Net Profits* ($ billion) | Sales Margin** (%) | Return on Net Worth |
|---|---|---|---|---|
| 1969 | 20.607 | 0.987 | 4.8% | 9.7% |
| 1970 | 21.069 | 0.719 | 3.4 | 7.0 |
| 1971 | 22.224 | 0.512 | 2.3 | 4.8 |
| 1973 | 26.503 | 1.441 | 5.4 | 12.5 |
| 1974† | 32.837 | 2.287 | 7.0 | 16.8 |
| 1975 | 32.044 | 1.801 | 5.6 | 12.1 |
| 1976 | 39.270 | 2.270 | 5.8 | 13.2 |
| 1977† | 45.750 | 2.367† | 5.2 | 12.0 |
| 1978 | 48.920 | 2.548 | 5.2 | 12.3 |
| 1979 | 55.359 | 3.724 | 6.7 | 16.0 |
| 1980E | 58.408 | 3.196 | 5.5 | 13.1 |

Source: Federal Trade Commission. Based on companies primarily engaged in sales of paper and allied products.

*Net profit after taxes.

**Ratio of after-tax earnings to net sales.

†Since revised, not directly comparable to prior years.

E Estimate based on first two quarters of 1980.

of Commerce statistics (Table 4-3) capital spending by the Paper Industry has increased rapidly between 1978 and 1980. This increase has been at a much faster rate than that undertaken by manufacturing in general. As discussed in Section 6, capital expenditures on pollution control have leveled off to a current rate of about $0.3 billion. Therefore, most of the recent capital expenditures have gone for new machinery and capacity expansion.

In line with typical industry procedure for many years, most of the additions to capacity have occurred at existing facilities. In 1978, only two new mills came on line and three more greenfield mills were under construction. According to the American Paper Institute,* 69 percent of new capacity tonnage in the 1980-82 period will come from new equipment at new and existing facilities, while 31 percent will come from modernizing existing production lines. The rate of capacity expansion has been steadily increasing since 1977, (See Table 4-4.) Included in this total is capacity lost to the shutting down of old machines and the closing of mills. For example, in the 1978-79 period, 35 paper and board machines and nine complete mills were closed, whose annual capacity was 1,514,000 short tons. The American Paper Institute estimates that between 1980 and 1982, 11 machines and one mill will be closed, with an annual capacity of 366,000 short tons.**

## Ratio Analysis of Major Firms

The ratios examined are long-run, non-liquid asset ratios. They were chosen because firms that are in serious financial difficulty (including those considering bankruptcy) base their most critical financial decisions on long-run prospects rather than short-run liquid assets. For example, a firm will declare bankruptcy as soon as negative long-term prospects are clear to them.

All financial ratios are for complete firms and not for just the pulp and paper segments of their business activities. For highly diversified corporations, this is an important constraint of ratio analysis. Standard and Poor's Corporation compiles financial statements (annual and quarterly) on a large number of U.S. corporations, and various ratios and other manupulations of these data are available through a service called COMPUSTAT. Meta Systems used data from this 3200-firm data base for this analysis.

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*American Paper Institute, Paper/Paperboard Woodpulp Capacity, 1978-1981 with additional data for 1982, p. 4, corrected.

**American Paper Institute, Paper/Paperboard Woodpulp Capacity, 1978-1981 with additional data for 1982, p. 9.

Table 4-3: Capital Spending:
Paper Industry and All Manufacturing ($ billion)

| | Paper Industry | | All Manufacturing | |
|---|---|---|---|---|
| Year | Capital Spending | Percent Change | Capital Spending | Percent Change |
| 1978 | 3.46 | -- | 67.65 | -- |
| 1979 | 4.88 | 41.0% | 78.92 | 16.7% |
| 1980 | 6.06 | 24.2% | 89.55 | 13.5% |

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Source: Department of Commerce, Survey of Current Business, various issues

TABLE 4-4. U.S. PAPER INDUSTRY CAPITAL SPENDING AND CAPACITY INCREASES FOR 1970-1980

| Year | Capital Spending** ($ billion) | Percent Change* | Paper/ Paperboard Capacity** (million tons/yr) | Percent Change* |
|---|---|---|---|---|
| 1970 | $ 1.65 | -- | 57.2 | -- |
| 1971 | 1.25 | -24.2% | 58.1 | 1.7% |
| 1972 | 1.38 | 10.4 | 60.0 | 3.1 |
| 1973 | 1.86 | 34.8 | 62.3 | 3.9 |
| 1974 | 2.58 | 38.7 | 63.8 | 3.9 |
| 1975 | 2.95 | 14.3 | 64.4 | 0.9 |
| 1976 | 3.27 | 10.1 | 65.7 | 2.0 |
| 1977 | 3.36 | 2.7 | 66.5 | 1.2 |
| 1978 | 3.46 | 2.9 | 67.4 | 1.4 |
| 1979 | 4.88 | 41.0 | 68.9 | 2.2 |
| 1980E | 6.06 | 24.2 | 71.0 | 3.0 |

Source: Pulp and Paper, July 1979, p. 104, Pulp and Paper, August 1980, p. 21, American Paper Institute.

*From prior year.

**Capital spending figure, Commerce Department; capacity figures, American Paper Institute. E = estimated.

No single ratio works as well as a combination of ratios. However, perhaps the most useful ratio in predicting failure (and probably the most common measure of profits) is "net income to total assets." Therefore it is the best single "financial profile" of the industry available. Unfortunately at the time of this analysis data were available only for 1978. Limitations notwithstanding, the combination of ratios listed below provide insight into the financial health of the top publicly-held pulp and paper firms.

Firms were grouped according to their net income to total asset ratio. Financial profile information on the 12 firms with the highest ratio and the ten firms with the lowest ratio are presented in Table 4-5. The high ratio group is much more profitable than the low ratio group, with a mean value of the net income to total assets ratio about 3.3 times that of the low group. While the two groups have nearly equal mean rankings by total sales, the high group has a smaller ratio of sales to working capital than the low group. The more profitable group is less dependent on paper sales, with a somewhat smaller mean ratio of paper sales to total sales than the less profitable group of firms. However, both groups contain some firms where paper is a very small percentage of their business, as well as firms which are exclusively in the paper business.

The last two columns present similar data on seventeen of the smallest firms. A few of these firms are in financial trouble as indicated by a negative net income to total assets ratio. However, even with these firms included, the mean value of this ratio for these small firms is higher than the mean for the lowest group. In addition, the highest value of this ratio is equal to the highest value in the most profitable group. Therefore, it can be concluded that the financial well-being of the smallest firms varies widely, and that small firms are not necessarily weak firms. The smallest firms do have a lower mean value of sales to working capital, and a higher current ratio than the other two groups. As expected, their mean value of paper as a percent of total sales is higher than the other two groups. Again the range is from paper being a very small part of the firms' business to paper being their total business.

A few additional general statements can be made. The high profit (high ratio) firms tend to be producers of paper, not board. A much higher proportion of the low profit (low ratio) firms are involved in the production of paperboard. However, this relationship between profit levels and products is not as strong for small firms. Of the seven most profitable small firms, two are involved in paperboard; and of the seven least profitable, three are involved in paperboard.

## TABLE 4-5. FINANCIAL PROFILES - 1978

| Ratio | High Net Income to Total Assets (12 Firms) | | Low Net Income to Total Assets (10 Firms) | | Small Firms - Based on Sales (17 Firms) | |
|---|---|---|---|---|---|---|
| | Mean | Range | Mean | Range | Mean | Range |
| Net Income to Total Assets | .119 | .09-.214 | .036 | .009-.047 | .059 | -.145-.214 |
| Sales to Working Capital | 6.62 | 1.60-10.24 | 7.30 | 5.29-11.9 | 6.55 | 1.34-23.47 |
| Current Ratio | 2.71 | 1.61-6.85 | 2.25 | 1.28-2.85 | 3.03 | 1.25-6.85 |
| Rank in Total Sales | 32 | 5-54 | 31 | 7-56 | N.A. | |
| Paper as Percent of Sales | 67.75 | 15-100 | 73.7 | 9-100 | 75.35 | 3-100 |

Source: Meta Systems and COMPUSTAT.

Information was requested on assets, revenues and expenses as part of the 308 Survey. This required mill level information from pro forma balance sheets, income statements and other financial records. The results of these requests were organized by subcategory. For this report, three major items were given attention: working capital in relation to total assets, five-year investment plans in relation to fixed assets, and expenses in terms of general, sales and administrative expenditures.

Working capital* is a measure of a mill's liquidity and is an indication of the mill's ability to meet short-term financial commitments (see Table 4-6). In addition, net working capital represents an investment of capital. Therefore, the magnitude of a company's net working capital has a direct bearing on return on investment. Comparing working capital to total assets** measures the proportion of the mill's capital which is liquid. The subcategory with the largest ratio of working capital to total assets is Nonintegrated Paperboard. These mills tend to be small, having one of the smaller mean values of total assets. This subcategory also is one of the smallest overall, having the third smallest sum of total assets. The subcategory, with the smallest ratio of working capital to total assets is Unbleached Kraft and Semi-Chemical. These mills on average are the largest, and have one of the highest mean total assets. This subcategory also has one of the larger sums of total assets.

Investment during the past five years as a percent of fixed assets ranges from a low of 21% for Unbleached Kraft (Bag) to a high of 64% for Fine Bleached Kraft and Soda and almost 67% for Miscellaneous Secondary Fiber (see Table 4-7). Fine Bleached Kraft and Soda is the second largest subcategory in terms of total investment, while Miscellaneous Secondary Fiber is one of the smaller in terms of total investment. So both large subcategories and small subcategories are investing heavily.

The ratio of mean mill general, sales and administrative expenditures to cost of goods sold ranges from a high of about 23 percent for BCT Bleached Kraft, to a low of 4.5 percent for Unbleached Kraft and Semi-Chemical (see Table 4-8). BCT Bleached Kraft is used in the

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*Working capital is equal to total current assets (including cash, accounts receivables, inventory, prepaid expenses, etc.) minus total current liabilities (including accounts payable, estimated tax liability, accrued income, etc.)

**Total assets equal fixed assets (at original cost)plus working capital.

TABLE 4-6. TOTAL ASSETS BY SUBCATEGORY ($000)

| Subcategory | Number Responding | Mean Assets | Standard Deviation | Total Assets | Ratio of Working Capital to Total Assets | Rank |
|---|---|---|---|---|---|---|
| Dissolving Kraft | * | * | * | * | * | * |
| Market Bleached Kraft | 10 | 99,551 | 64,358 | 995,513 | .140 | 12 |
| BCT Bleached Kraft | 8 | 157,864 | 66,336 | 1,262,913 | .078 | 24 |
| Fine Bleached Kraft & Soda | 21 | 133,856 | 75,044 | 2,810,983 | .092 | 23 |
| Unbl. Kraft (Linerboard) | 17 | 73,782 | 27,286 | 1,254,294 | .077 | 25 |
| Unbl. Kraft (Bag) | 11 | 81,030 | 54,317 | 891,327 | .094 | 22 |
| Semi-Chemical | 20 | 33,021 | 21,525 | 660,425 | .098 | 21 |
| Unbl. Kraft & Semi-Chemical | 10 | 158,321 | 86,977 | 1,583,214 | .054 | 28 |
| Dissolving Sulfite | 6 | 108,314 | 30,571 | 649,885 | .110 | 20 |
| Papergrade Sulfite | 16 | 67,983 | 50,914 | 1,087,739 | .150 | 10 |
| Groundwood-Thermo-Mechanical | * | * | * | * | * | * |
| Groundwood-Coarse, Molded, Newsprint | * | * | * | * | * | * |
| Groundwood-Fine Papers | 9 | 63,431 | 57,006 | 570,880 | .116 | 19 |
| Misc. Integrated Mills | 81 | 91,292 | 89,589 | 7,394,724 | .076 | 26 |
| Deink (Fine Papers) | 5 | 27,826 | 18,176 | 139,129 | .137 | 13-14 |
| Deink (Newsprint) | * | * | * | * | * | * |
| Deink (Tissue) | 13 | 28,791 | 52,946 | 374,277 | .275 | 2 |
| Tissue from Wastepaper | 18 | 6,239 | 15,645 | 112,293 | .129 | 17 |
| Paperboard from Wastepaper | 150 | 7,175 | 8,286 | 1,076,234 | .133 | 16 |
| Wastepaper Molded | 8 | 9,399 | 6,337 | 75,195 | .059 | 27 |
| Builders' Paper & Roofing Felt | 61 | 3,483 | 3,879 | 212,434 | .218 | 5 |
| Misc. Secondary Fiber Mills | 16 | 18,673 | 15,846 | 298,761 | .136 | 15 |
| Nonintegrated Fine Papers | 41 | 19,350 | 25,963 | 793,330 | .210 | 6 |
| Nonintegrated Tissue | 26 | 34,349 | 50,256 | 893,078 | .169 | 7 |
| Nonintegrated Lightweight | 11 | 15,116 | 15,336 | 166,273 | .137 | 13-14 |
| Nonintegrated Filter & Nonwoven | 14 | 4,166 | 3,788 | 58,326 | .230 | 4 |
| Nonintegrated Lightweight-Electrical Allowance | * | * | * | * | * | * |
| Nonintegrated Paperboard | 11 | 5,350 | 3,339 | 58,852 | .285 | 1 |
| Misc. Nonintegrated Mills | 35 | 11,240 | 13,911 | 393,411 | .238 | 3 |

Source: 308 Survey

Table 4-7. Investment During Previous Five Years ($000)

| Subcategory | Number Responding | Mean Investment | Standard Deviation | Total Investment | Ratio of Investment to Fixed Assets | Rank |
|---|---|---|---|---|---|---|
| Dissolving Kraft | * | * | * | * | * | * |
| Market Bl. Kraft | 10 | 85,567 | 54,663 | 855,670 | .402 | 12 |
| BCT BL. Kraft | 8 | 145,496 | 62,898 | 1,163,972 | .484 | 7 |
| Fine Bl. Kraft & Soda | 21 | 121,598 | 70,506 | 2,553,555 | .640 | 2 |
| Unbl. Kraft (Linerbd.) | 17 | 68,083 | 25,644 | 1,157,406 | .356 | 15 |
| Unbl. Kraft (Bag) | 11 | 73,419 | 45,719 | 807,614 | .213 | 24 |
| Semi-Chemical | 20 | 29,773 | 20,163 | 595,469 | .530 | 3 |
| Unbl. Kraft & Semi-Chem. | 10 | 149,730 | 80,795 | 1,497,299 | .514 | 4 |
| Dissolving Sulfite | 6 | 96,402 | 30,439 | 578,411 | .505 | 5 |
| Papergradè Sulfite | 16 | 57,771 | 43,932 | 924,328 | .399 | 13 |
| Groundwood-Thermo-Mech. | * | * | * | * | * | * |
| Groundwood-Coarse, Molded, Newsprint | * | * | * | * | * | * |
| Groundwood-Fine Papers | 9 | 56,046 | 51,706 | 504,417 | .499 | 6 |
| Misc. Integrated Mills | 81 | 84,392 | 84,127 | 6,835,726 | .352 | 17 |
| Deink (Fine Papers) | 5 | 24,024 | 16,845 | 120,121 | .242 | 22 |
| Deink (Newsprint) | * | * | * | * | * | * |
| Deink (Tissue) | 13 | 20,879 | 33,514 | 271,432 | .472 | 8 |
| Tissue from Wastepaper | 18 | 5,431 | 13,998 | 97,753 | .246 | 21 |
| Paperboard from Wastepaper | 150 | 6,220 | 7,591 | 933,035 | .412 | 10 |
| Wastepaper Molded | 8 | 8,842 | 6,385 | 70,738 | .241 | 23 |
| Builders' Paper & Roof. Felt | 61 | 2,724 | 2,751 | 166,170 | .373 | 14 |
| Misc. Secondary Fiber | 16 | 16,126 | 13,927 | 258,013 | .666 | 1 |
| Nonintegrated Fine Papers | 41 | 15,295 | 21,313 | 627,089 | N.A. | |
| Nonintegrated Tissue | 26 | 28,557 | 41,421 | 742,488 | .355 | 16 |
| Nonintegrated Lightweight | 11 | 13,047 | 11,724 | 143,513 | .322 | 18 |
| Nonintegrated Filter and Nonwoven | 14 | 3,208 | 3,379 | 44,914 | .439 | 9 |
| Nonintegrated Lightweight-Electrical Allowance | * | * | * | * | * | * |
| Nonintegrated Paperboard | 11 | 3,828 | 2,794 | 42,106 | 1.323 | |
| Misc. Nonintegrated Mills | 35 | 8,561 | 11,177 | 299,645 | .404 | 11 |

Source: 308 Survey

Table 4-8. General, Sales, and Administrative Expenditures by Subcategory ($000)

| Subcategory | Number Responding | Mean Expenditures | Standard Deviation | Total Expenditures | Ratio of Mean Expenditure to Cost of Goods Sold | Rank |
|---|---|---|---|---|---|---|
| Dissolving Kraft | * | * | * | * | * | * |
| Market Bl. Kraft | 10 | 4,002 | 4,651 | 40,018 | .092 | 8 |
| BCT Bl. Kraft | 8 | 18,379 | 24,563 | 147,029 | .232 | 1 |
| Fine Bl. Kraft & Soda | 21 | 10,499 | 22,832 | 220,479 | .116 | 5 |
| Unbl. Kraft (linerbd.) | 17 | 2,667 | 2,522 | 45,337 | .058 | 16-17 |
| Unbl. Kraft (Bag) | 11 | 2,965 | 2,773 | 32,612 | .056 | 18 |
| Semi-Chemical | 19 | 1,536 | 1,610 | 29,177 | N.A. | N.A. |
| Unbl. Kraft & Semi-Chem. | 10 | 3,650 | 2,495 | 36,500 | .045 | 20 |
| Dissolving Sulfite | 6 | 5,304 | 2,898 | 31,824 | .084 | 9 |
| Papergrade Sulfite | 16 | 7,505 | 9,848 | 120,075 | .123 | 4 |
| Groundwood-Thermo-Mech. | * | * | * | * | * | * |
| Groundwood-Coarse, Molded, Newsprint | * | * | * | * | * | * |
| Groundwood-Fine Papers | 9 | 3,266 | 2,253 | 29,396 | .054 | 19 |
| Misc. Integrated Mills | 79 | 4,380 | 7,547 | 345,988 | N.A. | N.A. |
| Deink (Fine Papers) | 5 | 1,587 | 926 | 7,933 | .058 | 16-17 |
| Deink (Newsprint) | * | * | * | * | * | * |
| Deink (Tissue) | 13 | 3,295 | 6,460 | 42,834 | .125 | 3 |
| Tissue from Wastepaper | 15 | 2,032 | 5,924 | 30,484 | N.A. | N.A. |
| Paperboard from Wastepaper | 146 | 661 | 899 | 96,545 | N.A. | N.A. |
| Wastepaper Molded | 6 | 1,247 | 399 | 7,482 | N.A. | N.A. |
| Builders' Paper & Roofing Felt | 49 | 280 | 574 | 13,715 | N.A. | N.A. |
| Misc. Secondary Fiber | 15 | 1,158 | 1,021 | 17,373 | N.A. | N.A. |
| Nonintegrated Fine Paper | 41 | 1,776 | 1,666 | 72,827 | .069 | 13 |
| Nonintegrated Tissue | 24 | 10,032 | 16,740 | 240,776 | N.A. | N.A. |
| Nonintegrated Lightweight | 11 | 1,186 | 876 | 13,049 | .068 | 14 |
| Nonintegrated Filter & Nonwoven | 14 | 491 | 409 | 6,872 | .095 | 7 |
| Nonintegrated Lightweight-Electrical Allowance | * | * | * | * | * | * |
| Nonintegrated Paperboard | 11 | 779 | 646 | 8,569 | .133 | 2 |
| Misc. Nonintegrated Mills | 35 | 1,794 | 3,100 | 62,805 | .112 | 6 |

Source: 308 Survey

production of many products, the most important being Bleached Foldingboard and Solid Bleached Board. Unbleached Kraft and Semi-Chemical is used primarily in the production of Unbleached Linerboard. In general, the mills with the lowest ratio of general, sales and administrative expenses to cost of goods sold are those producing undifferentiated products and integrated mills. Of the 29 subcategories, this ratio is available for only 21. The average ranking of the integrated subcategory is 12, indicating that in general, they have slightly lower than average ratios of general, sales and administrative expenditures to cost of goods sales. The secondary fiber and nonintegrated mills have an average ranking of about 8.

To summarize, working capital as a percent of total assets tends to be highest for small and/or secondary fiber and nonintegrated mills. General, sales and administrative expenditures in relationship to cost of goods sold also tends to be high for mills producing highly differentiated products, and for secondary fiber and nonintegrated mills; although this relationship is less strong. Investment during the past five years as a percent of fixed assets tends to be higher for integrated mills, with both large-mill and small-mill sectors experiencing heavy investment.

# Section 5

# Pricing

This section addresses the question of how cost increases due to BCPCT and BATEA treatment requirements are likely to affect prices in the pulp and paper industry. First, the historical relationship between costs and prices is reviewed, both for the industry as a whole and for smaller segments. The results emphasize the effect of capacity utilization rates on the ability to cover cost increases. Next, the effects of demand growth and elasticity on likely price impacts are discussed, and the prospects for each product sector assessed. Finally, the effect of the degree of competitiveness of markets, i.e. market structure, on pricing behavior is discussed, and the evidence for assessing the competitiveness of each product sector in the pulp and paper industry is examined.

## Price History

### Overall Industry Performance

The producers (wholesale) price index for the pulp, paper and allied products industry from 1960 to 1978 is shown in Figure 5-1. As the figure shows, the average price of pulp, paper and paperboard remained quite stable during the 1960's and up to 1972 where it began to rise but not as rapidly as that of other industrial commodities. In 1971 wage and price controls were put into effect and until March 1973 paper industry prices were held constant while prices of many of the materials used in its manufacture increased. Following the removal of price controls in 1973 and 1974, the paper price index increased at an average annual rate of 16 percent, reflecting increased demand. It has steadily risen since at a rate of about 5 percent per year, remaining slightly below the index for all industrial commodities.

The relatively constant prices prior to 1972 reflected stable operating costs, higher than average productivity increases, and stable capacity utilization rates.* Three major factors contribute to the cost of making paper: (1) raw materials - approximately 40 percent of cost; (2) labor - almost 25 percent; and (3) purchased energy - between 10 and 15 percent. Recent price increases have resulted from increases in these costs as well as the cost of building or expanding productive facilities and pollution control costs.

Figure 5-2 shows the profit margin (ratio of net income after tax to sales) history of the paper and allied products industry. During the

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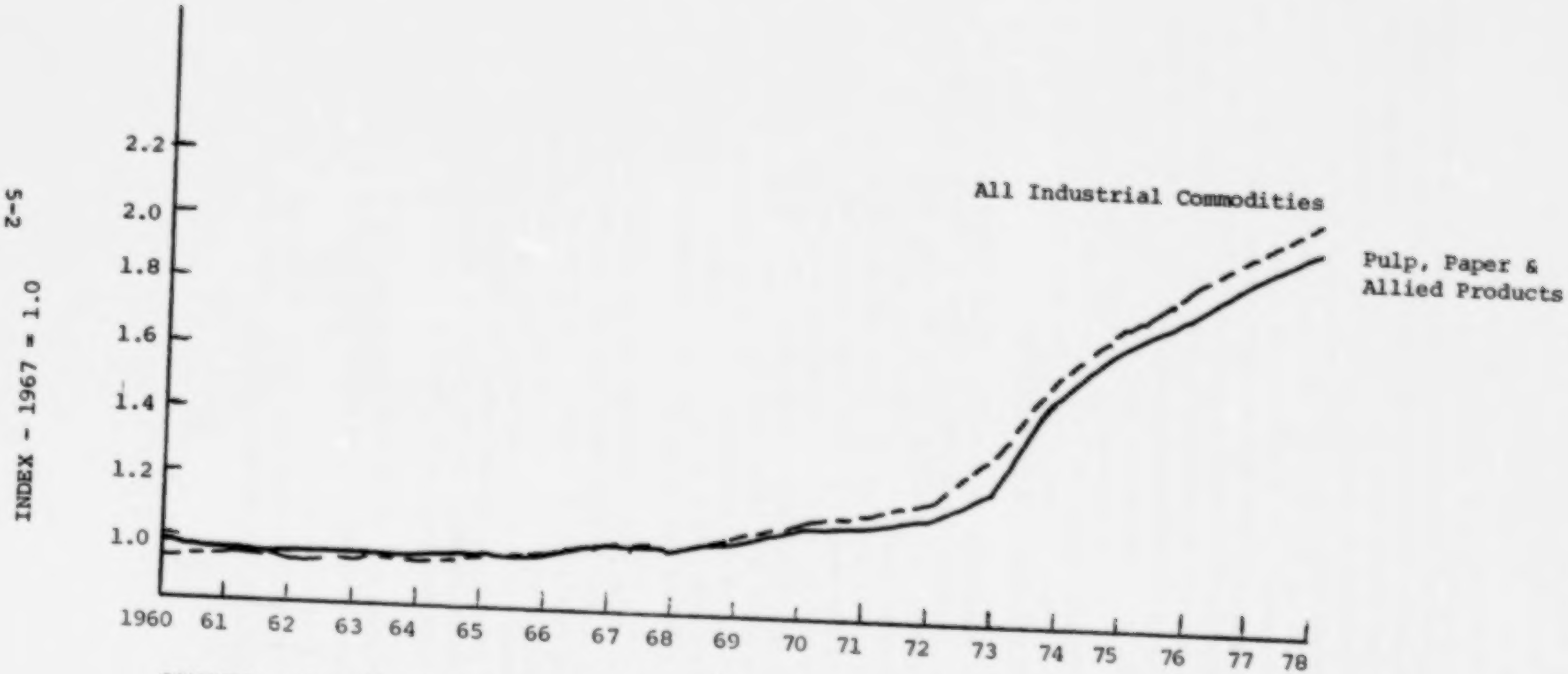
*Council on Wage and Price Stability, Price Increases and Capacity Expansion in the Paper Industry, Staff Report, December 1976, p. 3.

FIGURE 5-1

PRODUCER PRICE INDEXES

PULP, PAPER & ALLIED PRODUCTS VS. ALL INDUSTRIAL COMMODITIES

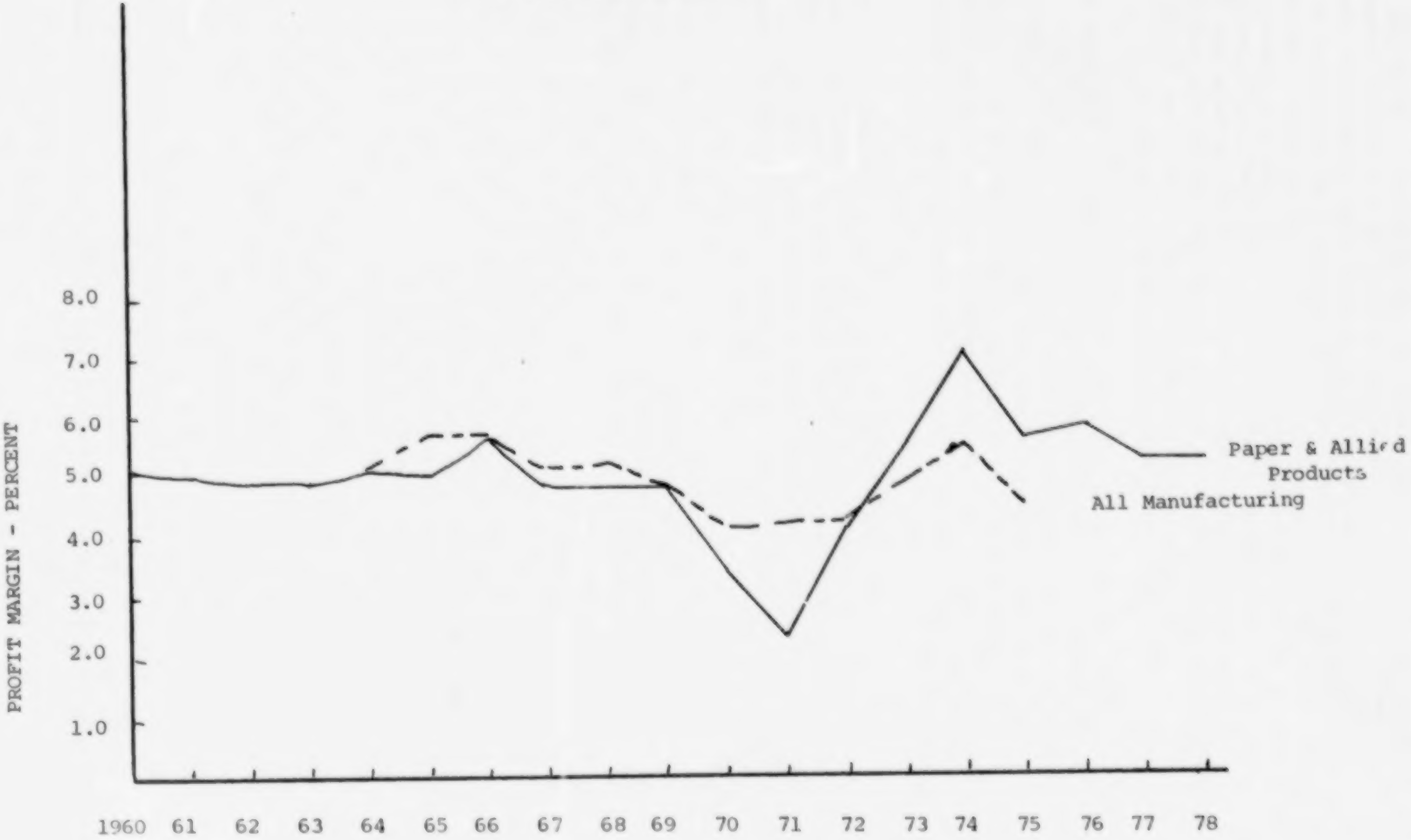


SOURCES: Council on Wage and Price Stability, Price Increases and Capacity Expansion In the Paper Industry, Staff Report, December 1976, p. 17

Pulp and Paper, North American Profile Issue, 1979, p. 22

FIGURE 5-2

PROFIT MARGINS - PAPER AND ALLIED PRODUCTS
VS. ALL MANUFACTURING



SOURCES: Council on Wage and Price Stability, Price Increases and Capacity Expansion In the Paper Industry, Staff Report, December 1976, p. 19

Pulp and Paper, North American Profile Issue 1979, p. 18

1960's the profit margin remained stable, slightly below the all manufacturing average. It fell considerably in the 1970-71 recession but climbed above its former average in 1974 when prices rose sharply after the lifting of controls. In 1974 the profit margin peaked at 7 percent and since then has returned to a level slightly above 5 percent. The Council on Wage and Price Stability concludes from this profit margin data that, as a whole, industry prices have risen sufficiently to cover cost increases.[*] Data submitted to the Council on Wage and Price Stability by members of industry showed that during the period from 1967 to 1976, operating costs generally rose less than prices, consistent with the profit margin data presented above.[**]

This conclusion is not accepted by everyone. Business Week reports in 1977 that paper prices have risen rapidly since 1967 but not fast enough to cover soaring costs.[***] An industry journal, Pulp and Paper, states that the principal reason for lower earnings in 1977 compared to 1976 was the inability of companies to raise prices fast enough to compensate for higher manufacturing costs.[†] Prices improved enough in 1978, however, to reverse the decline in profit margins caused by costs rising faster than prices.[††]

The producer price index for pulp, paper and paperboard rose 3.9 percent in 1977 compared to 7 percent for key industrial commodities, 13.7 percent for fuel and electricity and 10.8 percent for labor.[†††] In 1978 the price index for paper rose more than 4.8 percent, labor rates were up 10.4 percent, fuel 7 percent and industrial chemicals 1.6 percent.[Δ]

A key factor in industry pricing is the capacity utilization rate (production divided by capacity) for the industry. If it is about 92 percent or greater, the industry is usually able to raise prices faster than costs. Capacity utilization rate history for industry is shown in Figure 5-3.

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[*] Council on Wage and Price Stability, p. 2.

[**] Council on Wage and Price Stability, p. 18.

[***] Business Week, May 2, 1977, p. 54.

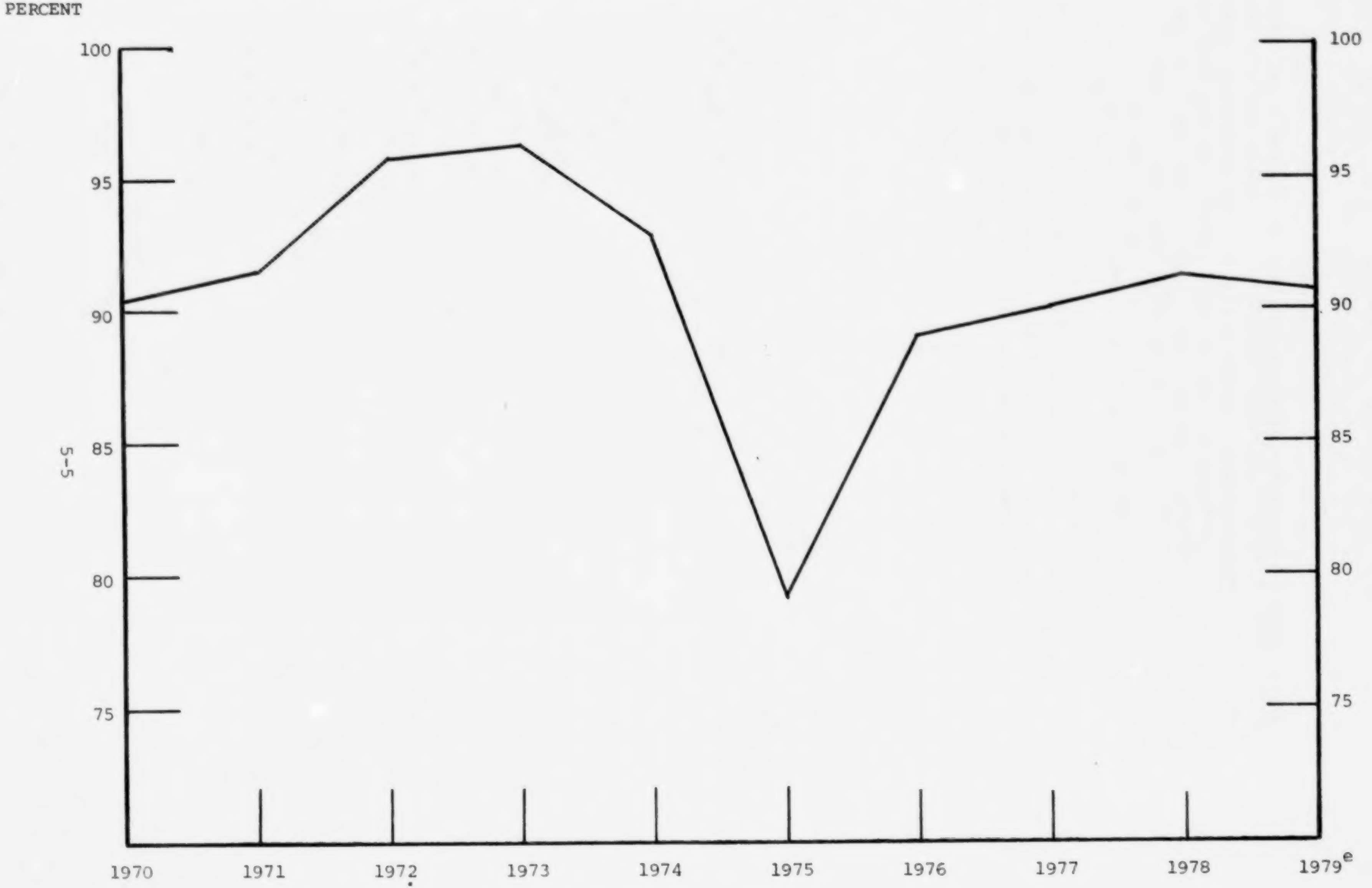
[†] Pulp and Paper, June 30, 1978, p. 22.

[††] Pulp and Paper, January 1979, p. 21.

[†††] Pulp and Paper, January 1979, p. 23.

[Δ] Pulp and Paper, June 30, 1979, p. 17.

FIGURE 5-3. CAPACITY UTILIZATION RATE FOR THE PAPER AND ALLIED PRODUCTS INDUSTRY



## Experience of Individual Product Sectors

The prices of most product sectors follow the general trends described above for the industry as a whole, with price remaining fairly stable during the 1960's and through 1972. Then most of them rise considerably due to the lifting of price controls, the pressure from accelerating cost increases, and the high capacity utilization rates which reflect tight demand conditions and provide an opportunity for price increases to be maintained. Product sectors which follow this general pattern include Coated Printing Papers, Solid Bleached Bristols, Special Industrial Papers and Foldingboard. In many sectors the price rises which occurred during 1973 and 1974 were maintained despite the 1975 recession and consequent severe drop in capacity utilization. Examples of product sectors which exhibit this trend are Uncoated Groundwood, Thin Papers, Unbleached Kraft Paper, Unbleached Kraft Linerboard, and Semi-Chemical Corrugating Medium. After 1975, prices of most grades continued to increase or at least hold constant.

Costs of production began increasing in some product sectors in the early 70's while prices continued to remain fairly stable. Such product sectors include Uncoated Groundwood, Coated Printing, Uncoated Freesheet, Solid Bleached Bristols and Thin Papers. Costs tended to increase faster in the period from 1973 to 1975 and prices rose during this time also for reasons mentioned above. Product sectors in which prices rose faster than costs through the end of 1978 were Coated Printing Paper and Newsprint; those in which costs rose faster than prices were Unbleached Kraft Linerboard, Unbleached Kraft Paper, Market Pulp and Uncoated Freesheet (especially uncoated book paper). Cost history data are not available for all product sectors.

## Demand Conditions

Demand conditions have an important effect on the ability of the industry to pass cost increases through to consumers. Producers have the most ability to pass costs through when demand is inelastic (i.e. not price-sensitive) and growing. Otherwise, a substantial part of the impact may be absorbed as reduced output and profit in the short run and closure in the longer run. This part describes demand conditions for the entire industry and the individual product sectors. Because demand elasticities were discussed in Section 2, they are only briefly reviewed here.

In general, the industry is considered mature. Consumption (production plus net imports) maintains a fixed relationship to GNP, being strongly related to the overall level of business activity of the economy. Nonetheless, demand for many of its products grew more rapidly than the economy during the 50's and 60's due to substitution of paper for glass, cloth and wood products and increased advertising and use of paper materials for product promotion. Other important factors affecting growth of demand include technological changes in end use sectors such as computers and dry copying machines. Recently, however, many of these markets have become saturated and plastics (e.g., wrapping and bags) have made substantial inroads in others. However, because of their unique attributes which provide a high level of performance in a wide variety of uses at low cost, demand for many industry products remains inelastic.

The rate of growth in much of the industry has leveled off and in some cases has declined. In the 1960's the relation between the demand for paper and paperboard products and economic activity was 53,000 tons of paper industry products consumed per billion dollars of real GNP.* In the years after the 1973-74 price rise, this figure has fallen to less than 50,000 tons per billion dollars. There is speculation that this lower level may continue to be maintained as customers have become accustomed to lower basis weights or the use of substitute products.

The first column of Table 5-1 presents a rough qualitative assessment of end-use demand growth in each product sector. This judgement is based on DRI's forecasts of demand indicators (size of end-use sector) and end-use factors (which reflect technological and other changes). Summaries of these data are presented in Appendix 7-B. Discussions of economic and technological trends in each product sector appear in Volume 2. Demand is fairly strong in most product sectors except Glassine and Greaseproof, Bleached Kraft Papers, Cotton Fibre, recycled board grades, and Dissolving Pulp.

Some product sectors have been severely affected by the penetration of their traditional markets by substitute materials. Examples of this trend are the substitution of polyethylene bags for Bleached Kraft Bags, of plastic film for Glassine and Greaseproof paper, of plastic containers for Molded Pulp products, and of plastic bottles for Solid Bleached Board. Other product sectors have not succumbed to penetration. For example, most Unbleached Kraft Papers have superior packaging properties and consequently have maintained market shares.

Technological change in end use markets has affected some products. Demand for Solid Bleached Bristols is down since there is increased use of computer magnetic tape rather than cards. Uncoated Freesheet use, on the other hand, has improved due to the burgeoning need for business forms and paper for computers and copying machines. Technological changes in product production have improved demand in some sectors such as Newsprint, Uncoated Groundwood and, very recently, Tissue, by improving product characteristics and therefore consumer acceptance.

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*Business Week, May 2, 1977, p. 56.

## TABLE 5-1. DEMAND/SUPPLY ASSESSMENTS OF EACH PRODUCT SECTOR

| | Demand Outlook | Demand Elasticity* $\varepsilon$ | Supply Elasticity $\eta$ | $\frac{\eta}{\eta-\varepsilon}$ Predicted ratio of price increase to cost increase |
|---|---|---|---|---|
| **Paper** | | | | |
| Unbleached Kraft | Increasing | 1.49 | .71 | .32 |
| Bleached Kraft | Static | 3.86 | 1.22 | .24 |
| Glassine | Declining | 2.14 | 2.34 | .52 |
| Spec. Industrial | Increasing | .73 | .51 | .41 |
| Newsprint | Increasing | .63 | .83 | .57 |
| Coated Printing | Increasing | .64 | .51 | .44 |
| Uncoated Freesheet | Increasing | .38 | 1.02 | .73 |
| Uncoated Groundwood | Increasing | 2.65 | .33 | .11 |
| Thin Papers | Increasing | 1.07 | .057 | .05 |
| Solid Bl. Bristols | Static | .41 | .59 | .59 |
| Cotton Fibre | Declining | 2.06 | 1.34 | .39 |
| Tissue | Increasing | .06 | .58 | .91 |
| **Board** | | | | |
| Unbl. Kraft Liner. | Increasing | .61 | .95 | .61 |
| Bl. Kraft Liner. | Static | .73 | 2.04 | .75 |
| Bl. Kraft Folding | Increasing | .73 | 1.13 | .61 |
| Semi-Chem. Corr. | Increasing | .61 | .91 | .60 |
| Recycled Liner | Increasing | .61 | 1.31 | .68 |
| Recycled Corr. | Increasing | .61 | .87 | .59 |
| Recycled Folding | Increasing | .73 | .42 | .37 |
| Constr. Paper & Bd. | Increasing | .68 | .097 | .13 |
| Molded Pulp | Increasing | n.a. | n.a. | n.a. |
| Solid Bl. Board | Static | 1.15 | .50 | .30 |
| All Other Board | Static | .63 | .32 | .33 |
| **Pulp** | | | | |
| Dissolving | Declining | .59 | 1.91 | .76 |
| Market | Increasing | | | |

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Source: DRI, Meta Systems estimates.

*Absolute value ($\varepsilon$ is negative).

The second column of Table 5-1 presents the own price elasticities of demand for each product sector. The derivation of these was discussed in Section 2. In most cases confidence intervals for these estimates are small. The table shows that the elasticity estimates of most of the product sectors are relatively inelastic. Exceptions are Bleached and Unbleached Kraft Papers, Glassine and Greaseproof Papers, Cotton Fibre Papers, Uncoated Groundwood Papers, Thin Papers, and Solid Bleached Board all with elasticities greater than one. Demand in some product sectors is extremely inelastic. These include Tissues, Uncoated Freesheet, and Solid Bleached Bristols. Recall also that several product sectors, Glassine and Greaseproof, Cotton Fibre, Uncoated Groundwood and Unbleached Kraft Papers have high cross-price elasticities.

In the standard theory of competitive markets, the impact of an increase in costs on price depends on the elasticities of supply and demand. Suppose the imposition of the treatment requirements causes the supply curve simply to be shifted up by a fixed amount. (This may not be accurate for the supply curve as a whole, but is a close approximation in the neighborhood of the intersection of the demand and supply curves.) If $\varepsilon$ is the elasticity of demand and $\eta$ is the elasticity of supply, then it can be shown that the percent price (P) increase resulting from a one percent increase in costs at the margin (MC) is equal to

$$\frac{dP/P}{dMC/MC} = \frac{\eta}{\eta-\varepsilon}. \qquad (5\text{-}1)$$

(The elasticity on the left is equal to the derivative dP/dMC because P=MC. See Appendix 5-A.)

The third and fourth columns of Table 5-1 show the elasticity of supply, $\eta$, and the price impact, $\eta/(\eta-\varepsilon)$, for each sector for which these data are available. The elasticities of supply were calculated from the supply curve equations in Appendix 2-E. It must be kept in mind that the supply elasticities are only approximate, because they are derived from the constructed supply curves. The limitations of this procedure are discussed in Sections 2 and 8. The price impact figures show that on the basis of elasticity estimates, more of the cost increase will be passed on in the board sectors than in the paper sectors. On the other hand, this is counterbalanced somewhat because demand growth is generally stronger in the paper sectors. Paper sectors face static demand.

## Effect of Market Structure on Pricing

### Overview

The basic theory of the price behavior of competitive markets is straightforward: the price rise resulting from an increase in costs depends on the elasticities of supply and demand. The theory is simple because it assumes that firms are small enough relative to the size of the market so that their actions do not measurably affect the overall market. The assumption that firms maximize profit provides a determinate market outcome. However, if firms are large enough to have some market power then strategic concerns affect their behavior, and there is no determinate market outcome.

A number of empirical observations have been made about oligopolistic markets, i.e. markets with a number of firms having some market power. Prices tend to change less often than in competitive markets because of price leadership and an unwillingness to cause changes which may upset market shares. The theory of the monopolistic firm suggests that price changes may be smaller than cost changes, but this result may not apply to oligopolistic markets. Markets with capital-intensive industries may be subject to price wars in times of slack demand because of low variable costs.

Although oligopolistic markets tend to change prices infrequently, this is probably less true in periods of inflation. Moreover, a specific action such as the imposition of pollution controls may provia a signal which allows all producers in a market to raise prices without fear that other firms will hold back in order to increase their market shares. Therefore it is not possible to make general statements about the relative behavior of competitive and oligopolistic markets in response to treatment costs. It is necessary to examine the experience of individual product sectors to gain further insight.

### Market Structure and Behavior of the Pulp and Paper Industry

The structure of the pulp and paper industry combines both competitive and oligopolistic characteristics. In general terms, it can be described as a commodity industry with minimal product differentiation. These characteristics combined with the large number of firms in the industry lead to the expectation that price competition is the dominant form of competition. During the 1960's, when demand weakened or when excess capacity existed, companies generally continued production at high rates and cut prices or gave discounts to customers. Recent industry conduct, however, has not always followed this pattern. During the recession of 1975, which was the worst demand decline since World War II, companies cut production rather than prices and as a result prices held relatively steady.* With the 1976 improvement in the economy, price competition increased. Commenting on demand tapering off during the second half of 1976, Pulp and Paper journal concluded that this problem was compounded by a "breakdown in pricing statesmanship" in which widespread price discounting occurred. This behavior eventually forced posted prices down on many grades.** An explanation suggested for this apparent inconsistency is that with the improvement in economic conditions, companies made aggressive attempts to expand market share by reducing prices which they were reluctant to do during the recession.***

With rapidly increasing manufacturing costs there is pressure on firms to raise prices. However, price increases have become a sensitive issue due to the large number of antitrust cases filed by the Justice Department, states and private companies alleging price fixing in such grades as corrugated boxes, folding cartons, bags, labels, and fine paper.† The large settlement costs and the reclassification of price fixing from a misdemeanor to a felony are bound to have some effect on the pricing behavior of the industry if only to increase companies' reluctance to take a price leadership position.

The market structures of the various product sectors within the pulp and paper industry differ considerably. A discussion of these mechanisms for several sectors is presented below based primarily on Guthrie's study of the industry.††

Market Pulp: Market pulp is an international commodity and has a worldwide market. Thus, import prices have a significant effect on domestic prices. For instance, Canadian producers' price changes influence U.S. producers and Scandinavian prices also affect U.S. prices, particularly when there is overcapacity in the industry. This can be clearly seen in the tremendous buildup of inventories in Europe during 1976-77 which precipitated a substantial decline in prices.

The market is not purely competitive. Sellers are relatively large and so are customers. In addition, prices are contract prices which generally remain unchanged over three-month periods. Occasionally, a large market pulp producer will initiate a price change followed by other firms.

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*Business Week, May 2, 1977, p. 55.

**Pulp and Paper, June 1977, p. 21.

***Pulp and Paper, January 1978, p. 53.

†Business Week, p. 57; The Wall Street Journal, May 4, 1978, p. 1 and 31; Paper Trade Journal, June 1-15, 1978, p. 22; February 15, 1979, p. 10; April 30, 1979, p. 17; October 15, 1980, p. 1; Pulp and Paper, September 1980, p. 25; and New York Times, October 21, 1980.

††John A. Guthrie, An Economic Analysis of the Pulp and Paper Industry, Washington State University Press, Pullman, WA, 1972.

Paper: Newsprint, unlike other paper grades, has a major international market. A high percentage of the supply consumed in the U.S. is produced by Canadian firms. As a result, the price is influenced and often set by these firms. All but a very small percentage of sales are on a contract basis. There is extensive evidence that price leadership is a prevalent practice although no one firm consistently takes the lead and not all firms follow the price changes. The acceptance of this competition-limiting practice is due to the inelasticity of demand, the high fixed costs involved in production, and the existence of customers (large newspaper publishers) who could exert pressure on suppliers through the media to reduce prices. Newsprint is clearly an oligopolistic market with a small amount of product differentiation.

Price history data for book and writing papers do not demonstrate the price leadership pattern as often as that for Newsprint, although it is probably practiced occasionally. The following observations lead to this conclusion: (1) there is a greater frequency of price changes in these sectors; (2) there are more buyers and sellers of these grades than of Newsprint; and (3) prices have risen relatively higher for these grades than for Newsprint.

Price behavior for Kraft Packaging Paper is similar to those for the Book and Writing Papers. Although sufficient data do not exist to allow a definitive conclusion, the market structures of packaging, book and writing grades appear to resemble differentiated oligopolies since product differentiation is important to each and the sellers are large relative to their markets.

Paperboard: In Kraft Linerboard most manufacturers are large and price changes are relatively infrequent. Price leadership may exist in this segment since sellers are sufficiently large that they are probably aware of their effects on competitors' activities.

Recycled Foldingboard price changes over the last 20 years have been more frequent than those of linerboard and have risen faster. These mills use wastepaper, tend to be smaller in size and more numerous. This segment may more closely approximate the competitive model and probably does not practice price leadership.

Individual Sector Assessments: Table 5-2 summarizes important aspects of the market structure of each product sector, including the number of firms, degree of concentration and recent behavior of prices and costs. These should indicate the extent to which different sectors are likely to show oligopolistic behavior. If such behavior is likely, the predictions of the competitive model about price behavior should be modified in light of other information about the sector.

The first and second columns of Table 5-2 list the number of firms and the share of capacity of the largest five firms, respectively, for each of the sectors. This information comes from the product profiles in Volume 2. A five-firm share greater than 50 percent implies a moderate degree of concentration and a share greater than 80 percent implies a high degree of concentration. The more competitive sectors would tend to have more firms and have a lower degree of concentration. Uncoated Freesheet and Special Industrial Papers, for instance, appear to be on the competitive side while Tissue and Molded Pulp products seem to be more oligopolistic. Comparisons between the "number of firms" figures are less clear, however, due to their dependence on the definitions of product sectors. Certain product sectors contain a much more heterogeneous collection of grades than others. Special Industrial Papers, Tissue, Thin Papers, All Other Paper, and All Other Board have significant product differentiation and hence market segmentation. A proper measure of concentration would include the market segment and any close substitutes. However, this information was not available, so the overall numbers must be taken with the appropriate reservations about the characteristics of each product sector.

The next three columns of Table 5-2 show for the period 1972 to 1978 the percentage increase in product price and in production costs in the sector as well as the frequency of price changes during that period. Observations are available for only certain product sectors. A comparison between the cost and price gains of the sectors shows some, such as Unbleached Kraft Papers and Thin Papers, whose costs increased significantly more than their prices, and others such as Uncoated Groundwood and Tissue whose prices rose more than their costs. Still others like Coated Printing Papers experienced equivalent price and cost increases. Relatively high price rises are an indication that the sector may be more competitive; the frequency of price changes is another measure of competitiveness. Oligopolistic sectors' prices tend to remain constant or rigid for long periods. The product sector data displayed in Table 5-2 are inconclusive concerning the two indicators just discussed. Some sectors with a relatively new number of price changes such as Uncoated Groundwood or Tissue have quite a high rate of price gain during the period considered. Unbleached Kraft Linerboard has a relatively high number of price changes but somewhat lower level

### TABLE 5-2. MARKET STRUCTURE AND PRICE BEHAVIOR BY PRODUCT SECTOR

| | No. of Firms | Percent share of capacity of top 5 firms | 1972-78 Percent price gain | 1972-78 Number quarterly price changes | 1972-78 Percent product cost change |
|---|---|---|---|---|---|
| Paper | | | | | |
| Unbleached Kraft | 33 | 48 | 45 | | 118 |
| Bleached Kraft | 14 | 52 | 80 | | |
| Glassine | 8 | n.a. | 95 | | |
| Spec. Industrial | 47 | 46 | 75 | | |
| Newsprint | 16 | 51 | 91 | | 100 |
| Coated Printing | 32 | 46 | 100 | 23 | 100 |
| Uncoated Freesheet | 51 | 38 | 87 | 18 | 90 |
| Uncoated Groundwood | 43 | 69 | 126 | 19 | 80 |
| Thin Papers | 12 | n.a. | 66 | 21 | 100 |
| Solid Bl. Bristols | 48 | 52 | 64 | 23 | 90 |
| Cotton Fibre | 14 | n.a. | 74 | | 100 |
| Tissue | 42 | 66 | 119 | 19 | 85 |
| All Other Paper | 63 | n.a. | 76 | | |
| Board | | | | | |
| Unbl. Kraft Liner. | 50 | 33 | 75 | 25 | |
| Bl. Kraft Liner. | 2 | | | | |
| Bl. Kraft Folding | 40 | 60 | 45 | | |
| Semi-Chem. Corr. | 46 | 30 | 71 | | |
| Recycled Liner | 87 | 29 | | | |
| Recycled Corr. | 87 | 29 | | 28 | |
| Recycled Folding | 87 | 29 | 70 | | |
| Constr. Paper & Bd. | 34 | 59 | 73 | | |
| Molded Pulp | 14 | 70+ | | | |
| Solid Bl. Board | 17 | | 60 | | |
| All Other Board | 87 | 29 | | | |
| Pulp | | | | | |
| Dissolving | 11 | 82 | | | |
| Market | 33 | 32 | 84 | | |

Source: Meta Systems estimates.

of price increase. The magnitude of price changes must be evaluated in relation to relative productivity increases, and information about this is difficult to obtain.

# Appendix 5-A

## Derivation of Price Impact Formula

Given equations for demand and supply in a competitive market, the problem is to derive the price increase that results from a simple vertical shift of the supply curve due to treatment costs. As long as the cost increase is not too large, this assumption about the change in costs is an adequate approximation of any change in the supply curve due to adding treatment costs. This is because price is affected only by the shape of the supply curve in the neighborhood of the intersection of the demand and supply curves.

Let the supply curve take the form

$$MC = f(Q) + c \tag{5A-1}$$

where MC is marginal cost, Q is output, and c the shift term. This form is not restrictive because c could be zero. If we substitute in the competitive relationship

$$P = MC, \tag{5A-2}$$

where P is price, and solve for output Q in equation (5A-1), we get

$$Q = S(P-c) \tag{5A-3}$$

where S is the inverse of f, i.e. $S = f^{-1}$.

Suppose the demand curve takes the general form

$$Q = D(P). \tag{5A-4}$$

Assuming demand equals supply, we have

$$D(P) = S(P-c) \tag{5A-5}$$

Totally differentiating (5A-5) yields

$$D'\,dP = S'\,dP - S'\,dc \tag{5A-6}$$

where an apostrophe denotes the first derivative, e.g. $D' = dD/dP$.

Recombining terms yields

$$\frac{dP}{dc} = \frac{S'}{S'-D'} \qquad (5A\text{-}7)$$

dP/dc measures the equilibrium effect of the vertical shift c on price. It also equals the percent change in price due to a one percent change in marginal cost, (dP/P)/(dMC/MC) because dMC = dc (the change in the shift factor equals the change in marginal cost) and price equals marginal cost by assumption. Multiplying the right side of (5A-7) by (P/Q)/(P/Q) yields the relation in the text

$$\frac{dP}{dc} = \frac{\eta}{\eta-\varepsilon} \qquad (5A\text{-}8)$$

where

$$\eta \equiv S' \frac{P}{Q} \text{ and}$$

$$\varepsilon \equiv D' \frac{P}{Q}.$$

Equation (5A-8) implies that costs are passed through completely only if supply is totally elastic ($\eta=\infty$) or demand is completely inelastic ($\varepsilon=0$).

## Section 6

## Effluent Control Guidelines, Costs and Other Regulatory Costs

### Introduction

The Federal Water Pollution Control Act Amendments of 1972 (PL 92-500), later amended by the Clean Water Act of 1977 (PL 95-217), requires that EPA revise and promulgate effluent limitations and standards for all industrial point sources of water pollution. As of January 1977, pursuant to Section 304(b) of the Clean Water Act, EPA had promulgated final regulations providing for effluent limitations representing the degree of effluent reduction attainable by the application of Best Practicable Control Technology Currently Available (BPT), for all subcategories, except Wastepaper Molded Products, Nonintegrated Lightweight Paper, Nonintegrated Filter and Nonwoven Paper, and Nonintegrated Paperboard. These limitations were to be achieved by mills in the Pulp, Paper and Paperboard Industry not later than July 1, 1977, according to Section 301(b) of the Clean Water Act. Subsequently, in September 1978, the BPT regulations for the Dissolving Sulfite Pulp subcategory for acetate grade pulp were remanded by the court. In response to this remand, the Agency proposed BPT regulations for acetate grade pulp production in the Dissolving Sulfite Pulp subcategory on March 12, 1980.

The BPT-based regulations establish daily maximum and maximum 30 day average limitations for five-day biochemical oxygen demand (BOD5),* total suspended solids (TSS), pH, and zinc (for groundwood subcategories only) per ton of product. These effluent limitations were to be met by mills using end-of-pipe treatment techniques, process and procedural innovations, and operating methods. In-plant control technologies for BPT as defined by EPA include strict management control over water use practices, minimization of water intake through reuse and recirculation of wastewater. End-of-pipe treatment technologies to meet BPT limitations include preliminary screening, primary sedimentation with a mechanical clarifier, biological treatment involving aerated stabilization basins or activated sludge treatment systems for all subcategories except Nonintegrated Tissue Paper, where the technologies include preliminary screening and primary sedimentation. For Groundwood subcategories, lime addition also is included.

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*BOD5 is defined as the quantity of dissolved oxygen used in the biochemical oxidation by microorganisms of organic matter in a five day period.

The pollution control options analyzed are described below. In developing the effluent limitations options and in assessing their costs to the industry, it was assumed that BPT technology had been installed by all mills and that BPT discharge limitations have been attained.*

## Option Descriptions**

### Best Practicable Control Technology Currently Available (BPT) Effluent Limitations

The recommended technology for BPT for Wastepaper Molded Products has been identified as biological treatment, which is the technology upon which BPT limitations are based for all other subcategories of the Secondary Fiber segment of the Pulp, Paper and Paperboard Industry.

It has been determined that wastewater discharges from the Nonintegrated Lightweight Paper, Nonintegrated Filter and Nonwoven Paper, and the Nonintegrated Paperboard subcategories are similar in nature to discharges from the Nonintegrated Tissue Paper subcategory. For these three subcategories, the recommended technology for BPT has been identified as primary clarification, which is the technology on which BPT limitations are based for the Nonintegrated Tissue Paper subcategory.

### Best Available Technology Economically Achievable (BAT) Effluent Limitations

The factors considered in establishing the BAT level of control include environmental considerations such as air pollution, energy consumption, and solid waste generation; the costs of applying the control technology; the age of process equipment and facilities; the process employed; process changes; and the engineering aspects of applying various types of control techniques.

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*In the case of Wastepaper Molded Products, none of the mills are meeting the BPT limitations, and investments will be necessary. Due to the nature of the Molded Pulp Products market and our inability to obtain price information for this product sector, it was not feasible to develop a demand function. Therefore, the impact on production costs of implementing each option was estimated and are presented in Section 7. The impact of the options on closure of mills in this product sector also was analyzed. (See Section 8.)

**For a more detailed description of these options, see the Development Document for Proposed Effluent Limitations Guidelines, New Source Performance Standards, and Pretreatment Standards for the Pulp, Paper, and Paperboard and the Builders' Paper and Board Mill Point Source Categories, prepared for EPA by E. C. Jordan Co., Inc.

The primary determinant of BAT is effluent reduction capability using economically achievable technology. As a result of the Clean Water Act of 1977, the achievement of BAT has become the national means of controlling the discharge of toxic pollutants. Four regulated toxic pollutants are discharged from mills in the Pulp, Paper, and Paperboard Industry. These pollutants are chloroform, trichlorophenol, pentachlorophenol, and zinc. The proper application and operation of the technologies that formed the basis of BPT effluent limitations were found to control chloroform and zinc. Chemical substitution for slimicides and biocides containing trichlorophenol and pentachlorophenol was selected for control of these pollutants to trace levels without expensive end-of-pipe treatment.

### Best Conventional Pollutant Control Technology (BCT) Effluent Limitations

The 1977 amendments to the Clean Water Act established BCT for discharges of conventional pollutants from existing industrial point sources. Conventional pollutants are defined by the Act as BOD5, TSS, fecal coliform, and pH, plus any additional pollutants defined by the Administrator as "conventional" (oil and grease).

BCT is not an additional limitation, but replaces BAT for the control of conventional pollutants. BCT requires that limitations for conventional pollutants be assessed in light of a "cost-reasonableness" test, which involves a comparison of the cost and level of reduction of conventional pollutants from the discharge of publicly owned treatment works (POTWs) to the cost and level of reduction of such pollutants from a class or category of industrial sources.

Four different BCT options were analyzed, in addition to the option EPA is proposing. Three of these effluent control options were based on the development of model mills for each subcategory. The technical contractor developed the model mills using data requested from the industry on mill processes, products, production process controls, raw waste load, etc. A model mill represents the typical operation of mills within the subcategory and is used to estimate the cost of implementing selected production process controls and effluent treatment technologies. Up to three mill sizes were selected for each subcategory depending on actual mill size variations. The fourth effluent control option was based on the effluent quality characteristics of the best performing mills in each subcategory, those with exemplary treatment systems.

Alternative Option 1. The effluent limitations are based on the technology upon which BPT is based for each subcategory plus additional in-plant production process controls. No additional end-of-pipe technology beyond BPT is contemplated in this option. Effluent limitations are proposed for each subcategory of the industry and are based on specific controls that include segregation of non-contact cooling water, use of dry barking operations, collection of spills and leaks for reprocessing, increased efficiency of pulp washing, collection and reuse of paper machine spills, improvement in save all operation, and effluent recycle/reuse. These controls primarily achieve reductions in water use, wastewater discharge, and BOD5 raw waste loadings. Implementation of process controls will improve performance of existing primary and secondary biological treatment systems due to the reductions of raw waste loadings. Evaluation of Alternative Option 1 by the BCT cost-reasonableness test shows that the Nonintegrated Paperboard subcategory fails the test. For this subcategory, BCT is equal to BPT.

Alternative Option 2. The effluent limitations are based on the addition of chemically assisted clarification of BPT final effluents for all integrated and secondary fiber subcategories and for the Nonintegrated Fine Papers subcategory (for these subcategories BPT is based on biological treatment). It is assumed that additional solids-contact clarifiers will be added using alum as a coagulant and polymer as a flocculant aid. For the remaining nonintegrated subcategories, for which primary treatment was the basis of BPT, effluent limitations are based on the addition of biological treatment. Evaluation of Alternative Option 2 by the BCT cost-reasonableness test shows that the Paperboard from Wastepaper, Tissue from Wastepaper, Wastepaper Molded Products, Builders' Paper and Roofing Felt, Nonintegrated Tissue Papers, Nonintegrated Lightweight Papers, Nonintegrated Filter and Nonwoven Papers, and Nonintegrated Paperboard subcategories fail this test. For these subcategories the less stringent Alternative Option 1 forms the basis for BCT if it passes the test.

Alternative Option 3. The effluent limitations are based on Alternative Option 1 plus the addition of chemically assisted clarification for all integrated and secondary fiber subcategories and for the Nonintegrated Fine Papers subcategory (for these subcategories BPT is based on biological treatment). It is assumed that additional solids-contact clarifiers will be added using alum as a coagulant and polymer as a flocculant aid. For the remaining nonintegrated subcategories, for which primary treatment was the basis of BPT, effluent limitations are based on the application of Alternative Option 1 plus the addition of biological treatment. Evaluation of Alternative Option 3 by the BCT cost-reasonableness test shows that the Tissue from Wastepaper, Wastepaper Molded Products, Builders' Paper and Roofing Felt, Nonintegrated Tissue Papers, Nonintegrated Lightweight Papers, Nonintegrated Filter and Nonwoven Papers, and Nonintegrated Paperboard subcategories fail this test. For these subcategories the less-stringent Alternative Options 1 or 2 form the basis for BCT if they pass the BCT cost-reasonableness test.

Alternative Option 4. The effluent limitations are based on the levels attained by best performing mills in the respective subcategories. Best mill performance for a subcategory is generally the average at all mills where BPT effluent limitations are attained. The technologies for achieving Alternative Option 4 effluent limitations vary depending on the type of treatment systems that are employed at mills in each subcategory. Evaluation of Alternative Option 4 by the BCT cost-reasonableness test shows that the Nonintegrated Tissue Papers, Nonintegrated Lightweight Papers, Nonintegrated Filter and Nonwoven Papers, and Non-Integrated Paperboard subcategories fail this test. For these subcategories, the less stringent Option 1 forms the basis for BCT if it passes the test.

Proposed Regulation. The effluent limitations EPA has proposed are based on the Alternative Option 4 effluent limitations for all subcategories for which the BCT cost-reasonableness test passes. In those subcategories where the cost-reasonableness test fails, Nonintegrated Tissue Papers, Nonintegrated Lightweight Papers, Nonintegrated Filter and Nonwoven Papers, and Nonintegrated Paperboard, the less stringent Alternative Option 1 forms the basis of BCT if it passes the cost-reasonableness test. The only exceptions are the Dissolving Sulfite Pulp and the Builders' Paper and Roofing Felt subcategories for which BCT is established at the BPT level because of the projected severe economic impact. (See Section 7.)

Treatment systems commonly employed at mills in the integrated segment, Nonintegrated Fine Papers, and Deink subcategories in which BPT was based on biological treatment include aerated stabilization basins, activated sludge systems, and oxidation ponds. It is assumed that aerated stabilization basin treatment systems will be upgraded through the addition of spill prevention and control systems, by increasing aeration capacity, and by providing additional settling capacity. For the Nonintegrated Fine Papers subcategory, it is assumed that equalization will also be provided. Conversion to the extended aeration activated sludge process was considered to be the probable method of upgrading the performance of aerated stabilization basins located in colder climates. It is assumed that activated sludge systems will be upgraded through the addition of spill prevention and control systems, by providing equalization, by increasing the capacity of aeration basins and by providing for operation in the contact stabilization mode, and by increasing the size of clarification and sludge handling equipment. It is assumed that oxidation ponds will be upgraded through the addition of rapid sand filtration to remove algae that can contribute to the discharge of large levels of suspended solids.

At mills in the nonintegrated subcategories in which BPT is based on primary treatment, it is assumed that existing primary treatment systems will be supplemented by additional in-plant production process controls. No additional end-of-pipe technology beyond BPT is contemplated.

At best performing mills in the remaining subcategories (Paperboard from Wastepaper, Tissue from Wastepaper, Wastepaper Molded Products, and Builders' Paper and Roofing Felt), extensive use also is made of production process controls to reduce wastewater discharge. Therefore, Alternative Option 4 for these subcategories is based on the application of the same technology as discussed in Alternative Option 1: the technology on which BPT is based plus the application of additional production process controls.

Table 6-1 presents a summary of the total capital cost and the total annual cost to the industry. Appendix 6-A presents the cost effectiveness of each option in terms of the BCT Cost Test.

## New Source Performance Standards (NSPS)

The basis for new source performance standards (NSPS) is the best available demonstrated technology, including in-plant controls and end-of-pipe treatment technologies, that reduce pollution to the maximum feasible. The NSPS effluent limitations for control of toxic and conventional pollutants are based on the application of production process controls to reduce wastewater discharge and raw waste loadings and end-of-pipe treatment in the form of biological treatment for all subcategories except Nonintegrated Tissue Papers, Nonintegrated Lightweight Papers, Nonintegrated Filter and Nonwoven Papers, and Nonintegrated Paperboard, where end-of-pipe treatment is in the form of primary clarification. This option includes both production process controls that form the basis of BPT and BCT Alternative Option 1 in combination with end-of-pipe treatment with a design basis identifcal to BCT Alternative Option 4. This option ensures substantial reductions in the discharge of the toxic pollutant chloroform from subcategories where pulp is bleached with chlorine or chlorine-containing compounds. In addition, effluent limitations are based on chemical substitutions to significantly reduce the amounts of zinc, trichlorophenol and pentachlorophenol discharged.

This option was not analyzed separately. Instead, the economic analysis of each of the five BCT options described above assumed that a specific portion of the capacity expansion would be considered as new sources, and would meet the NSPS. The costs assigned to these capacity expansions were those developed by the technical contractor to meet NSPS.

Table 6-1. Summary of Option Costs

| Regulations | Cost to Industry† (million $) Capital | Annual |
|---|---|---|
| BPT - Molded Pulp Products** | * | * |
| BCT - Total Industry | | |
| Alternative Option 1 | 906.2 | 281.0 |
| Alternative Option 2 | 1730.6 | 770.0 |
| Alternative Option 3 | 2290.4 | 918.8 |
| Alternative Option 4 | 1450.1 | 460.5 |
| Proposed Regulation | 1359.1 | 430.2 |

Source: Meta System estimates. See Section 7 for details.

†For capacity forecast to exist at end of 1983.

*Suppressed due to confidentiality.

**For three subcategories (Nonintegrated Lightweight, Nonintegrated Filter and Nonwoven, and Nonintegrated Paperboard) BPT has no additional cost since technologies are already in place.

## Pretreatment Standards for Existing Sources (PSES)

Pretreatment standards for existing sources are designed to prevent the discharge of pollutants that pass through, interfere with, or are otherwise incompatible with the operation of publicly owned treatment works (POTWs). The Clean Water Act of 1977 adds a new dimension by requiring pretreatment for pollutants, such as heavy metals, that pass through POTWs in amounts that would violate direct discharger effluent limitations or limit POTWs' sludge management alternatives, including the beneficial use of sludges on agricultural lands. To accomplish this, the toxic pollutants trichlorophenol, pentachlorophenol, and zinc are controlled through chemical substitution, as described in the option above. Chloroform is effectively controlled through the application of biological treatment, the type of treatment most commonly used at POTWs. Therefore, this option does not include any specific control technology for the removal of chloroform. Since the cost of the PSES is minimal, it was not included in the economic analysis.

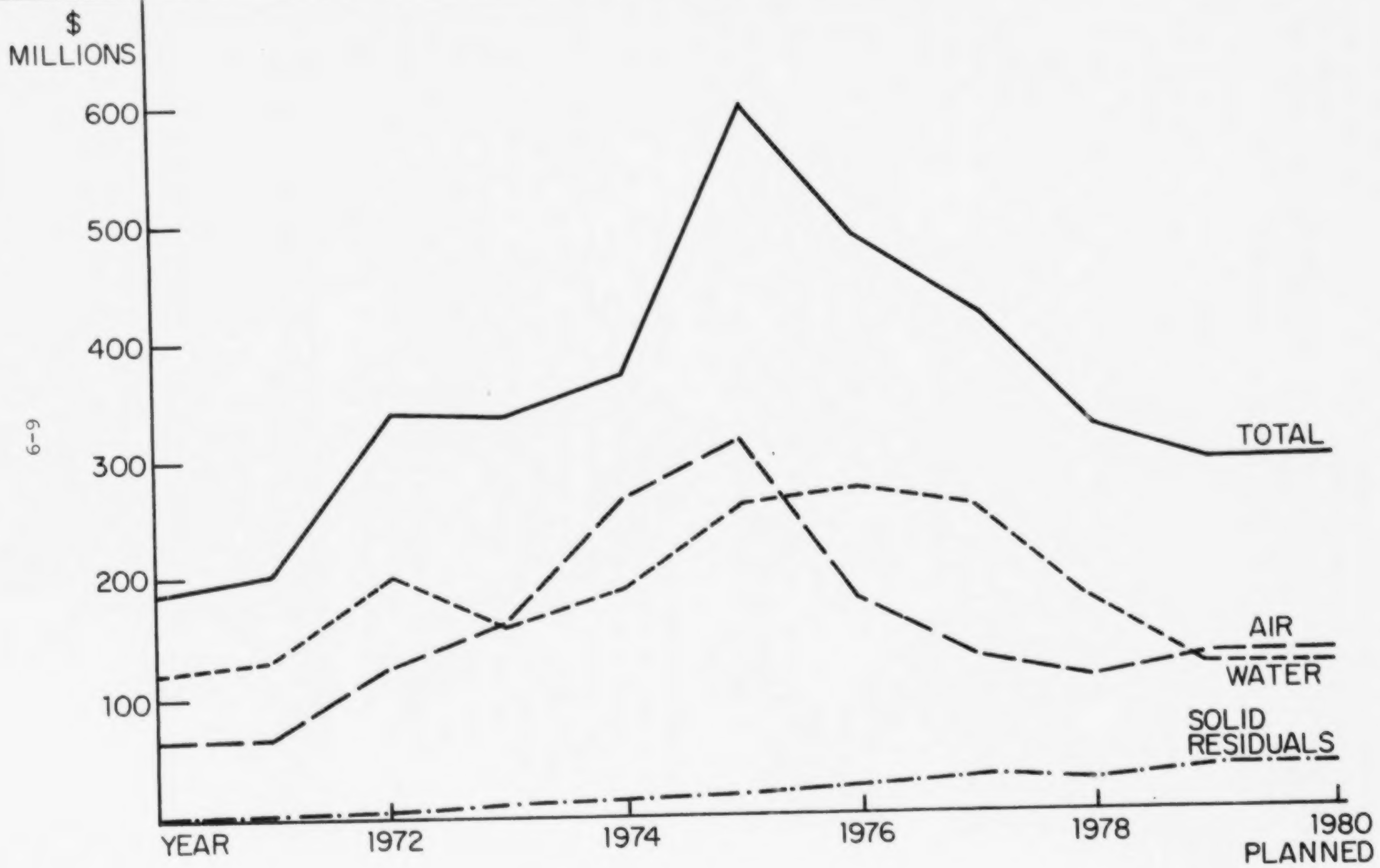
## Pretreatment Standards for New Sources (PSNS)

New indirect dischargers, like new direct dischargers, have the opportunity to incorporate the best available demonstrated technologies including process changes, in-plant control measures, and end-of-pipe treatment, and to use plant site selection to ensure adequate treatment system installation. The pretreatment option considered for new dischargers to POTWs is the same as for PSES.

## Past Expenditures on Environmental Pollution Control

Expenditures for pollution control plant and equipment by the Pulp, Paper and Paperboard Industry over the last decade are shown in Figure 6-1. Total environmental control capital investment peaked in 1975 at over 600 million dollars, declined rapidly in the next five years and is expected to remain at this level in 1980 according to the U.S. Bureau of Economic Analysis (BEA). Also depicted in Figure 6-1 is a breakdown of expenditures by type of pollution. Investment in solid waste disposal facilities has remained only a small part of the total, rising to near fifteen percent in the last couple of years. Air pollution control capital expenditures peaked in 1975 at about 235 million dollars, declined through 1977 and have remained fairly constant since. Investment in water pollution abatement rose rapidly through 1972, declined slightly and then continued to increase until 1975 when it reached about 275 million dollars, remained near that level through 1977 and declined thereafter.

FIGURE 6-1. Pollution Abatement Capital Expenditures
Paper and Allied Products Inventory



Sources for Figure 6-1: 1970-72: National Council of the Paper Industry for Air and Stream Improvement, Inc. as reported in Pulp and Paper North America/Profile, June 30, 1979, p. 23. 1973-78: U.S. Bureau of the Census, Current Industrial Reports, Pollution Abatement Cost and Expenditure, 1977 and Advance Report 1978. 1979-80: U.S. Bureau of Economic Analysis, Survey of Current Business, June 1980.

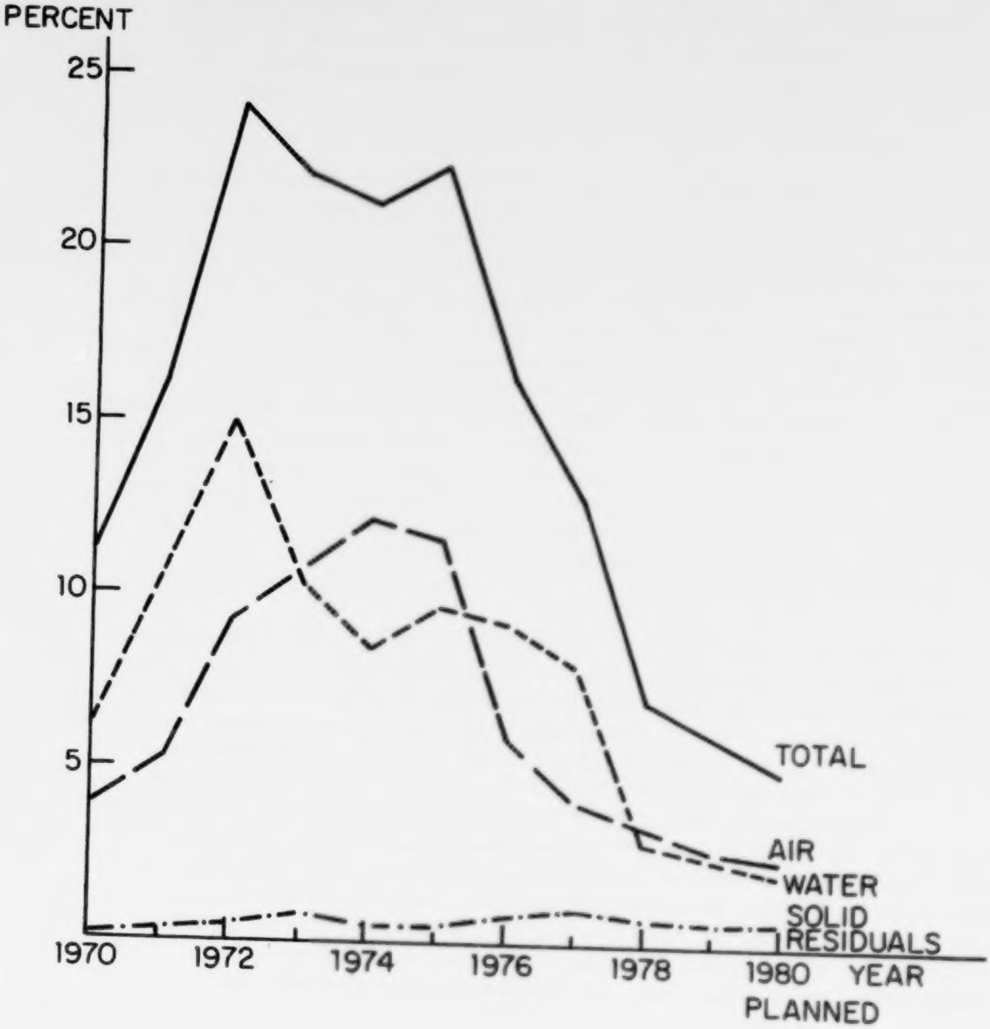
The level of pollution control capital expenditures by industry are affected by two factors. The first is the level of investment in productive capital, as new plant and equipment must meet pollution control requirements. The second factor is deadlines for compliance with regulations promulgated under environmental legislation such as the Clear Air Act or the Clean Water Act. The impact of such deadlines is illustrated in Figure 6-1 by the reduction of air pollution control expenditures after 1975 when compliance was required with national primary ambient air quality standards and by the similar reduction in water pollution abatement investment after 1977 when best practicable control technology (BPT) was to be in place. Industry has not yet encountered such deadlines concerning solid waste disposal.

The effects of these deadlines are more sharply outlined in Figure 6-2 which shows pollution control investment as a percent of total capital investment. Use of this ratio eliminates the first factor mentioned above affecting pollution control investment, that which generally accompanies new productive investment. Significant drops in expenditures are shown for air pollution control after 1975 and for water pollution control after 1977. The proportion of investment allocated to pollution control of all types reached a high point near 25 percent in 1972 and remained quite high through 1975 after which it decreased rapidly to near five percent, where it is at present. The high proportions of investment allocated to water pollution control and correspondingly to total environmental control in 1971 and 1972 is partly due to the fact that total investment decreased by 24 percent in 1971 and increased only ten percent in 1972, probably due to the price controls in effect at that time.

The proportion of total capital invested in pollution control by the paper industry is compared to other industries with high pollution control investments and with all manufacturing industries in Figure 6-3. Paper industry pollution control investment was a higher proportion of total investment than that of other industries except petroleum from 1973 through 1975. Thereafter this ratio decreased more rapidly than that of other industries so that by 1978 it was close to the average for all manufacturing industries and remained near that level through planned 1980 investments. Other industries, such as the chemical industry, were closer to the average throughout the period shown, and spent proportionately less of their capital investment on pollution control. The level of capital expenditures assigned to pollution control has been decreasing over time for all manufacturing industries.

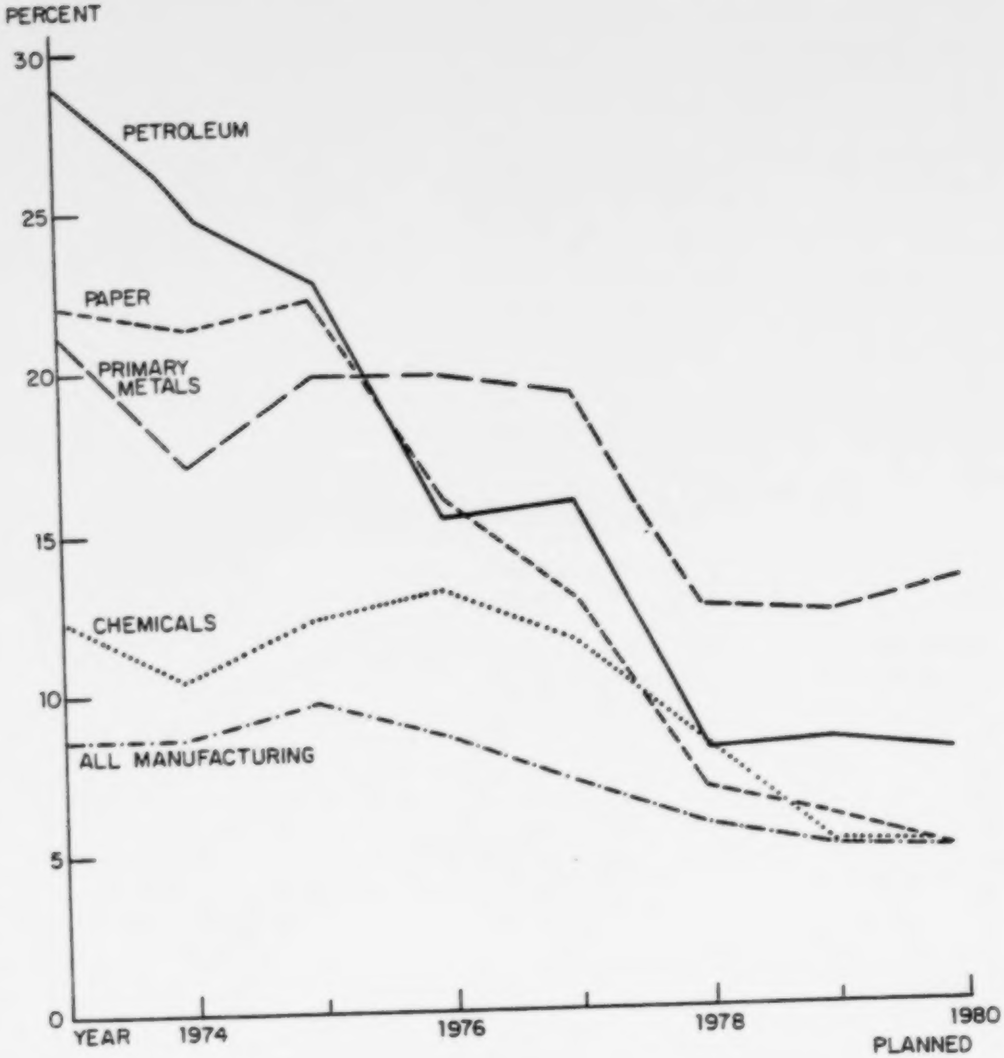
Figure 6-4 depicts the percentage of new capital expenditures invested in pollution abatement over time along with other time series

FIGURE 6-2. Pollution Abatement Capital Expenditures as a Percentage of Total New Capital Expenditures, Paper and Allied Products Inventory



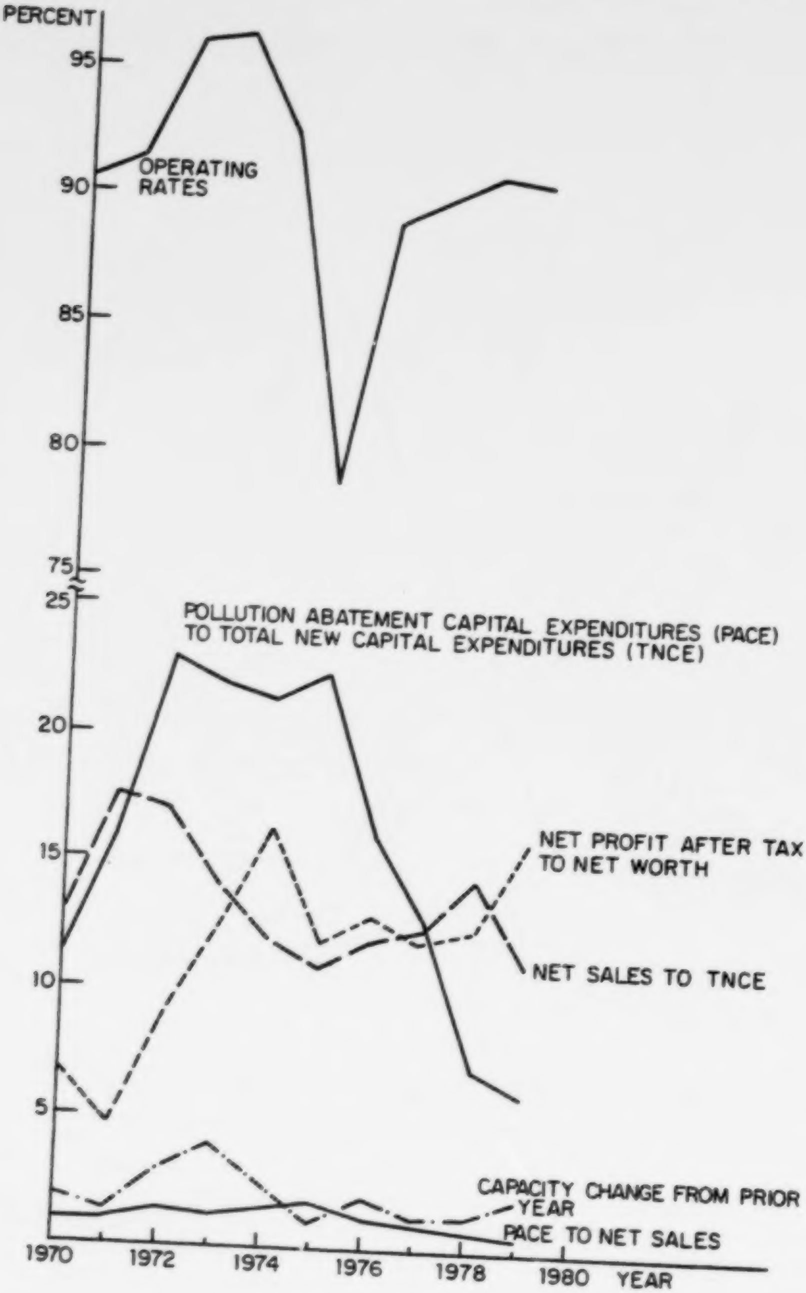
Source: 1970-72 : National Council of the Paper Industry for Air and Stream Improvement, Inc. as reported in Pulp and Paper, North America/ Profile, June 30, 1979, p. 23. 1973-77: U.S. Bureau of the Census, Current Industrial Reports, Pollution Abatement Cost and Expenditures, 1977 and 1977 Census of Manufacturers Preliminary Statistics. 1978-80: U.S. Bureau of Economic Analysis, Survey of Current Business, June 1980.

FIGURE 6-3. Pollution Abatement Capital Expenditures as a Percentage of Total New Capital Expenditures for Selected Industries



Source: 1973-77: U.S. Bureau of the Census, Current Industrial Reports, Pollution Abatement Cost and Expenditures, 1977 and 1977 Census of Manufactures, Preliminary Statistics; 1978-80: U.S. Bureau of Economic Analysis, Survey of Current Business, June 1980.

FIGURE 6-4. Comparison of Investment Allocated to Pollution Control With Other Time Series Data for the Paper And Allied Products Industry



Sources for Figure 6-4:

(1) Operating Rates: Pulp and Paper, North American/Profile, June 30, 1979, p. 21;

(2) PACE to TCNE: 1970-1971: National Council of the Paper Industry for Air and Stream Improvement, Inc. as reported in Pulp and Paper, June 30, 1979, p. 23; 1972: 6th Annual McGraw-Hill Survey, Pollution Control Expenditures, McGraw-Hill Publications, May 18, 1973; 1973-1977: U.S. Bureau of the Census, Current Industrial Reports, Pollution Abatement Cost and Expenditures, 1977 and 1977 Census of Manufacturers Preliminary Statistics; 1978-1979: U.S. Breau of Economic Analysis, Survey of Current Business, June 1980;

(3) Net sales to TNCE and Net Profit After Tax to Net Worth: American Paper Institute (API), Statistics of Paper and Paperboard, October, 1979, pp. 29 and 39, and personal communication with API Statistics Department, August, 1980;

(4) Capacity Change From Prior Year: API, Capacity Survey, 1979;

(5) PACE to Net Sales: see second reference above for PACE and third reference for Net Sales.

data for the Pulp, Paper and Paperboard Industry. Profitability of the industry was highest in 1974 (17 percent) after price controls were lifted, decreased in 1975 during the recession, remained near twelve percent until 1979 when it again increased to 16 percent. It is interesting to note that the first increase took place during a time of proportionately high pollution control investment and that the ratio remained constant during a period of decreasing pollution control expenditures. Profitability is affected by operating rates which reflect the level of demand and the ability of producers to pass along cost increases in terms of higher prices. Nineteen seventy five was a year of very low operating rates, 79 percent, as shown in Figure 6-4. Capacity changes from year to year are related to new plant and equipment investment and follow the same general pattern as the profitability ratio.

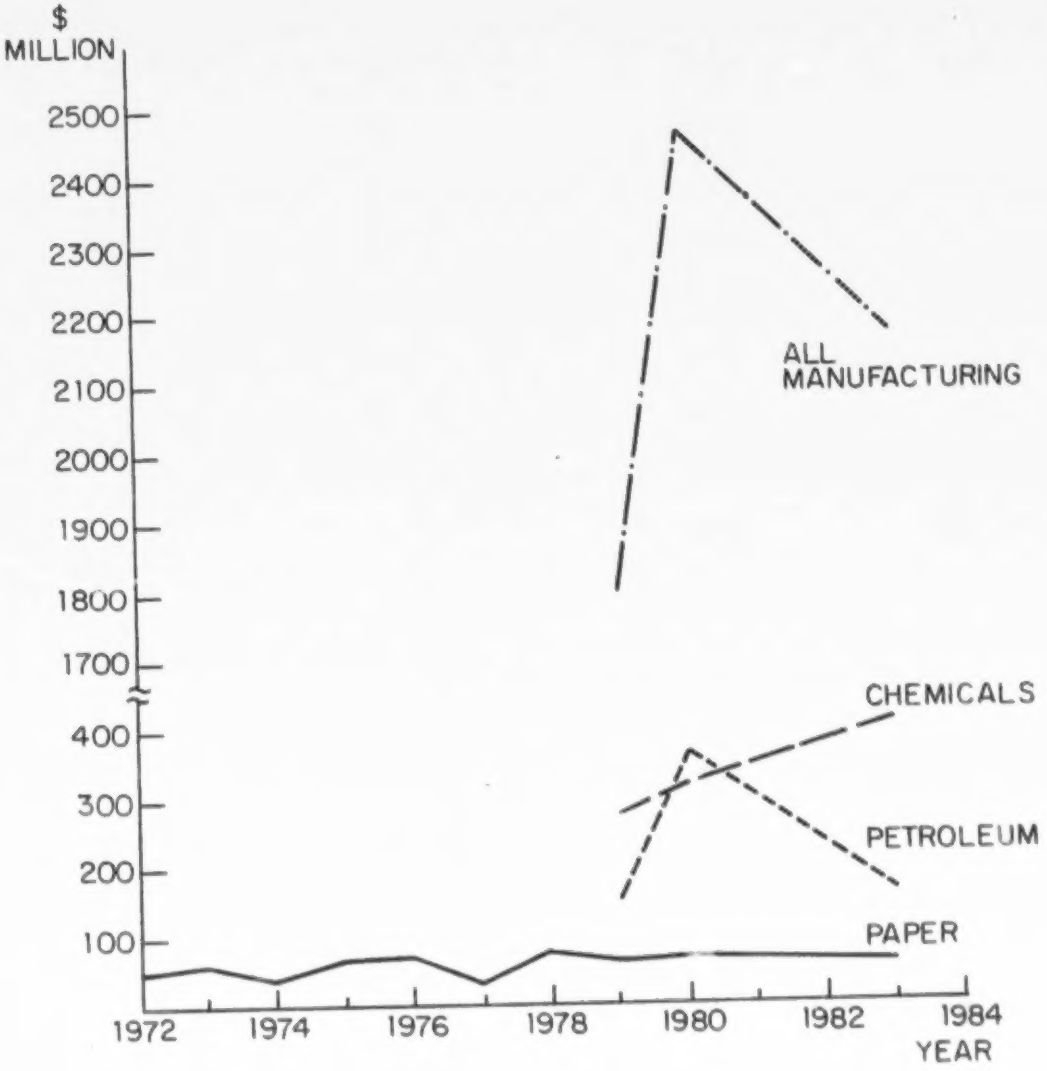
Return on productive investment is shown in Figure 6-4 as the ratio of net sales to total capital expenditures. This indicator is highest at about 17 percent in 1971 and 1972, decreases to a low near 10 percent in 1975, increases again gradually through 1978 and decreases in 1979. As might be expected, the ratio of pollution abatement expenditures to net sales tends to move in the opposite direction although much smaller in magnitude as the return on productive investment, with the exception of the years 1971, 1973, and 1979.

In addition to pollution abatement controls, another federal source of required investment is the Occupational Safety and Health Act (OSHA). Figure 6-5 presents paper industry capital expenditures for compliance with OSHA regulations. These expenditures have remained around fifty or sixty million dollars annually since 1972, and are expected to continue at this level. Paper industry expenditures were significantly below those of the chemical and petroleum industries in 1979 and 1980. Data for other years for these industries were not available.

OSHA compliance capital investment has equaled only about one to two percent of total new capital expenditures in each year since the early 1970s. (See Table 6-2). Adding these OSHA capital expenditures to the total environmental capital expenditures presented above would increase them by one to two percent, and the general conclusions remain the same. Appendix 6-B summarizes the pollution abatement and OSHA compliance costs for 1970 through 1980.

The 308 Survey also reported capital and operating expenditures on pollution control by pulp, paper and paperboard mills between 1971 and 1978. Table 6-3 compares the expenditure levels as reported in the 308 Survey with those discussed above. Total capital expenditures as

FIGURE 6-5. Investment in Employee Safety and Health. Paper and Other Industries



Source: McGraw-Hill Publications Co., Annual Survey of Investment in Employee Safety and Health, 1973 through 1980.

TABLE 6-2. OSHA EXPENDITURES AS A PERCENTAGE OF TOTAL NEW CAPITAL EXPENDITURES (TNCE)

| Year | TNCE ($ million) | OSHA Capital Expenditures ($ million) | OSHA as Percentage of TNCE |
|---|---|---|---|
| 1972 | 1380 | 50 | 3.6 |
| 1973 | 1860 | 58 | 3.1 |
| 1974 | 2580 | 44 | 1.7 |
| 1975 | 2950 | 65 | 2.2 |
| 1976 | 3270 | 69 | 2.1 |
| 1977 | 3360 | 40 | 1.2 |
| 1978 | 3460 | 77 | 2.2 |
| 1979 | 4880 | 60 | 1.2 |
| Pl. 1980 | 7060 | 66 | 0.9 |
| Pl. 1983 | 6185 | 60 | 1.0 |

Source: McGraw-Hill Publications Co., Annual Survey of Investment in Employee Safety and Health, 1973-1980.

TABLE 6-3. COMPARISON OF REPORTED ENVIRONMENTAL CONTROL COSTS FOR PULP, PAPER AND PAPERBOARD MILLS ($\$ \times 10^3$)

| | Air Pollution | Water Pollution | Solid Residuals | OSHA Compliance | All Other | Total |
|---|---|---|---|---|---|---|
| Total Capital 1971-78* | 1,529,000 | 1,537,000 | 137,000 | 396,000 | - | 3,599,000 |
| Total Costs** | | | | | | |
| Capital | 513,715 | 1,370,330 | 71,120 | 72,390 | 17,780 | 2,045,335 |
| Operating | 157,480 | 274,955 | 43,180 | 26,670 | 4,445 | |
| Costs per Unit of Capacity ($/ton)** | | | | | | |
| Capital | 717.55 | 3,829.05 | 228.60 | 285.75 | 50.80 | |
| Operating | 279.40 | 882.65 | 133.35 | 88.90 | 31.75 | |

Sources: *See Appendix 6-B
**308 Survey

reported in the 308 Survey are only 57 percent of those publicly reported. However, water pollution control capital expenditures are in closer agreement, with the 308 Survey reporting about 89 percent of that publicly reported. Air pollution control expenditures are the least in agreement.

Past pollution control expenditures as reported in the 308 Survey were aggregated by subcategory. The more meaningful cost data are those normalized by the size of the mill, i.e., costs per ton of capacity. Among those subcategories which have had the highest per unit costs are Papergrade Sulfite, Nonintegrated Lightweight, Fine Bleached Kraft and Soda, and Dissolving Kraft.

## Future Expenditures on Environmental Pollution Controls

For the future, it is difficult to predict the level of capital expenditures that will be allocated by the Pulp, Paper and Paperboard Industry to environmental control other than for water pollution for which we have available detailed cost estimates. From past history it appears that total expenditures have been decreasing and are leveling off at about five percent of total new capital investment. However, new requirements are likely to increase expenditures on pollution control, at least in the short-run. As discussed above, industry allocates a higher proportion of its capital investment to pollution control as opposed to productive facilities when it is required to meet certain standards or to employ certain technology. After these deadlines are passed (and presumably the requirements are met) pollution abatement expenditures decrease to a level consistent with the level of investment in new plant and equipment. Although the setting of deadlines which will require increased capital investment by the pulp and paper industry are anticipated in the near future, good data concerning the costs involved are not available. Therefore, the economic analysis assumes that pollution control costs, other than water pollution, will remain at their 1978 levels. Since this underestimates the total cost of pollution control to the pulp and paper industry, the anticipated federal regulations are discussed below.

The Resource Conservation and Recovery Act (RCRA) was passed in 1976 to improve the management of solid wastes in order to protect human health and the environment and to promote resource recovery and conservation. These objectives are to be achieved through state programs authorized by EPA which regulate the management of hazardous waste from generation through approved disposal. Land disposal of other solid wastes are also to be regulated under state programs which meet minimum federal requirements. Hazardous waste regulations were promulgated on May 19, 1980, which define types of wastes covered and provide guidelines for management and disposal. Implementation will begin in 1981 and it may be five or more years before all sites have approved permits. Compliance costs to the Pulp, Paper and Paperboard Industry are not known at this time.

The purpose of the 1970 Clear Air Act is to protect the public health and welfare from harmful effects of air pollution. To carry on this purpose EPA has developed national ambient air quality standards (NAAQS) and the states are adopting State Implementation Plans (SIP) to meet these standards. For areas of states which already meet the national standards, states must develop prevention of significant deterioration (PSD) plans. EPA also must produce new source performance standards (NSPS) and national emission standards for hazardous air pollution from stationary sources (NESHAPS).

The 1977 amendments to the Clean Air Act served to delay its implementation. In addition, there have been delays in approval of state SIPs and the attainment of ambient air standards. The states are revising their SIPs and most have not met the recent target dates for approval. Among the states, there is wide variation in the degree to which air quality controls have been implemented so far. The level of capital investment which has been expended by pulp and paper mills and that which is required to be spent in the future depends on the states in which the mills are located. A firm with mills in the states without controls may have a long way to go with its air emissions control investment compared to other companies which have substantially completed control programs because of their location in states with stricter regulations.

During 1980 and 1981 EPA will review its NAAQS for carbon monoxide, nitrogen dioxide, sulfur dioxide and particulates. Current attainment targets are 1982 for particulates, sulfur dioxide and nitrogen dioxide and 1987 for ozone and carbon monoxide. New legislation may cause delays of one or more years in the deadlines and in state plan approval. EPA also periodically updates its NSPS which apply to new sources and to existing sources which are modified after approval of the regulations. Updates will take place in 1980, 1981 and 1982. EPA will develop guidelines for including visibility protection in SIPs in 1980 and for PSD plans in 1982. Also in 1980 EPA will finalize a regulation which establishes policy and procedures for dealing with airborne carcinogens under its NESHAPS program. In the future EPA will develop generic standards for volatile organic chemical carcinogens as they are listed as hazardous air pollutants. Dates for these regulations are not available. Many of the new regulations, updates and reviews of existing standards mentioned above have impacts on the Pulp, Paper and Paperboard Industry and its future capital expenditures on air pollution controls. Future costs, however, are not available.

The Occupational Safety and Health Act of 1970 was passed to protect workers in their working environment. The Occupational Safety and Health Administration (OSHA) within the U.S. Department of Labor implements this legislation by promulgating and enforcing workplace safety and health regulations. In March 1977, a new direction was taken in the administration of the act toward prevention of occupational disease by concentrating effort on high-risk industries. Standards have been set by OSHA for worker exposure to several substances such as benzene, lead, cotton dust and chlorine, a few of which affect the Pulp, Paper and Paperboard Industry. Several cases have been brought to court by industry groups, such as the American Petroleum Institute, challenging the rulings. OSHA has developed a generic carcinogen policy which classifies chemicals into four categories depending on evidence of carcinogenicity. Classification into the first two categories would trigger regulatory action.*

As to future regulation affecting the pulp and paper industry, OSHA may promulgate a noise standard in 1980 which has been pending since 1975.** This could require the institution of engineering controls by the industry. In addition, the National Institute for Occupational Safety and Health (NIOSH) is preparing a criteria document to assess the degree of hazard caused by wood dust in the working environment. NIOSH conducts many of these assessments and it is unlikely that this study will lead to the promulgation of a standard.† OSHA's first candidate list of chemicals being considered for regulation under its carcinogen policy recommends ten or twenty substances for priority regulation. It does not include any chemicals used by the Pulp, Paper and Paperboard Industry. It thus appears that probably one but not many new OSHA regulations will be promulgated over the next several years which will require additional capital investment of an unknown amount by this industry.

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*Category I includes confirmed carcinogens based on human data, or based on tests in two mammalian species or in one species if the tests have been replicated. Category II includes substances whose carcinogenicity has been reported but for which the evidence is only suggestive or is positive in only one species and not yet replicated.

**Personal communication with Mr. Richard Klinzing, of the American Paper Institute, August 1980.

†Personal conversation with Dr. John Festa, of the American Paper Institute, August 1980.

## User Charges

The 308 Survey included user charge and flow data for indirect dischargers. The data for each subcategory was disaggregated by mill size and by region. Since many subcategories had no mills or only one mill in certain size or regional breakdowns, very little could be concluded. However, two general observations can be made. Integrated subcategories have the fewest indirect dischargers. Of the five regions, the Northwest has the fewest indirect dischargers.

## Appendix 6-A. Summary of the BCT Test Ratios

One criteria used to compare options is the BCT Test, or cost effectiveness ratio. The BCT Test compares the cost for industry to remove a pound of conventional pollutants to the cost incurred by a publicly owned treatment works (POTW). For industry, a ratio is calculated representing the annual incremental cost to remove a pound of conventional pollutants beyond BPT in terms of dollars per pound. For an option to be meet the BCT Test, this industry ratio must be less than the POTW cost effectiveness ratio. The following tables present, for each option, the ratio in dollars per pound of pollutant removed for each subcategory in terms of 1978 capacity and pollutant levels.

## TABLE 6A-1. BCT ANALYSIS - PROPOSED REGULATION

| Subcategory | Subcategory Average $/lb | Range | Option Selected |
|---|---|---|---|
| Dissolving Kraft | 0.31 | 0.29 - 0.35 | 4 |
| Market Bleached Kraft | 0.48 | 0.37 - 0.81 | 4 |
| BCT Bleached Kraft | 0.44 | 0.31 - 0.84 | 4 |
| Alkaline Fine | 0.46 | 0.32 - 0.73 | 4 |
| Unbleached Kraft | 0.67 | 0.44 - 2.09 | 4 |
| Semi-Chemical | 1.02 | 0.56 - 1.84 | 4 |
| Unbleached Kraft & Semi-Chemical | 0.98 | 0.68 - 2.10 | 4 |
| Dissolving Sulfite Pulp | -* | - | BPT |
| Papergrade Sulfite | 0.42 | 0.24 - ∞ | 4 |
| Groundwood Thermo-Mechanical | 0.62 | 0.60 - 0.62 | 4 |
| Groundwood-CMN Paper | 0.65 | 0.54 - 1.57 | 4 |
| Groundwood-Fine Paper | 0.75 | 0.62 - 1.59 | 4 |
| Deink | 0.68 | 0.43 - 1.75 | 4 |
| Tissue from Wastewater | 0.47 | 0.23 - 1.52 | 4 |
| Paperboard from Wastepaper | 0.10 | 0.05 - 0.31 | 4 |
| Wastepaper Molded Products | 0.64 | 0.53 - 1.04 | 4 |
| Builders' Paper and Roofing Felt | -* | - | BPT |
| Nonintegrated Fine | 0.23 | 0.15 - 0.79 | 4 |
| Nonintegrated Tissue | 0.44 | 0.35 - 0.86 | 1 |
| Nonintegrated Lightweight | 0.75 | 0.47 - 3.24 | 1 |
| Nonintegrated Filter and Non-Woven | 0.78 | 0.71 - 3.65 | 1 |
| Nonintegrated Paperboard | -** | - | BPT |

*BCT equals BPT ude to severe economic impact.

**BCT equals BPT as no regulatory option passes the BCT cost test.

TABLE 6A-2. BCT ANALYSIS - ALTERNATIVE OPTION 1

| Subcategory | Subcategory Average $/lb | Range |
|---|---|---|
| Dissolving Kraft | 1.04 | 1.00 - 1.07 |
| Market Bleached Kraft | 0.29 | 0.25 - 0.40 |
| BCT Bleached Kraft | 0.31 | 0.28 - 0.45 |
| Alkaline Fine | 0.95 | 0.89 - 1.63 |
| Unbleached Kraft | 0.40 | 0.27 - 1.28 |
| Semi-Chemical | 0.65 | 0.43 - 0.80 |
| Unbleached Kraft & Semi-Chemical | 0.42 | 0.31 - 0.69 |
| Dissolving Sulfite Pulp | 0.77 | 0.58 - 1.10 |
| Papergrade Sulfite | 0.20 | |
| Groundwood Thermo-Mechanical | 0.08 | 0.16 - 0.44 |
| Groundwood-CMN Paper | 0.44 | 0.07 - 0.11 |
| Groundwood-Fine Paper | 0.73 | 0.31 - 1.83 |
| Deink | 0.14 | 0.09 - 0.70 |
| Tissue from Wastewater | 0.51 | 0.17 - 1.94 |
| Paperboard from Wastepaper | 0.10 | 0.05 - 0.31 |
| Wastepaper Molded Products | 0.64 | 0.53 - 1.04 |
| Builders' Paper and Roofing Felt | 0.44 | 0.31 - 0.58 |
| Nonintegrated Fine | 0.37 | 0.20 - 2.10 |
| Nonintegrated Tissue | 0.44 | 0.35 - 0.86 |
| Nonintegrated Lightweight | 0.75 | 0.47 - 3.24 |
| Nonintegrated Filter and Non-Woven | 0.78 | 0.71 - 3.65 |
| Nonintegrated Paperboard | 3.95 | 2.89 -17.86 |

## TABLE 6A-3. BCT ANALYSIS - ALTERNATIVE OPTION 2

| Subcategory | Subcategory Average $/lb | Range |
|---|---|---|
| Dissolving Kraft | 0.48 | 0.46 - 0.49 |
| Market Bleached Kraft | 0.61 | 0.50 - 0.75 |
| BCT Bleached Kraft | 0.46 | 0.42 - 0.63 |
| Alkaline Fine | 0.74 | 0.64 - 1.16 |
| Unbleached Kraft | 0.64 | 0.50 - 1.03 |
| Semi-Chemical | 0.54 | 0.48 - 0.83 |
| Unbleached Kraft & Semi-Chemical | 0.48 | 0.42 - 0.62 |
| Dissolving Sulfite Pulp | 0.30 | 0.29 - 0.31 |
| Papergrade Sulfite | 0.42 | 0.37 - 0.66 |
| Groundwood Thermo-Mechanical | 0.64 | 0.57 - 0.86 |
| Groundwood-CMN Paper | 1.06 | 0.84 - 2.44 |
| Groundwood-Fine Paper | 1.13 | 0.93 - 2.39 |
| Deink | 0.60 | 0.34 - 1.76 |
| Tissue from Wastewater | 2.00 | 1.01 - 5.05 |
| Paperboard from Wastepaper | 1.84 | 0.93 - 6.47 |
| Wastepaper Molded Products | 2.85 | 2.30 - 4.97 |
| Builders' Paper and Roofing Felt | 3.16 | 2.57 - 3.72 |
| Nonintegrated Fine | 0.78 | 0.50 - 3.17 |
| Nonintegrated Tissue | 5.62 | 4.03 -12.69 |
| Nonintegrated Lightweight | 5.23 | 3.48 -16.66 |
| Nonintegrated Filter and Non-Woven | 6.09 | 4.91 - 9.81 |
| Nonintegrated Paperboard | 14.63 | 13.42 -40.15 |

## TABLE 6A-4. BCT ANALYSIS - ALTERNATIVE OPTION 3

| Subcategory | Subcategory Average $/lb | Range |
|---|---|---|
| Dissolving Kraft | 0.53 | 0.52 - 0.55 |
| Market Bleached Kraft | 0.63 | 0.51 - 0.79 |
| BCT Bleached Kraft | 0.52 | 0.47 - 0.73 |
| Alkaline Fine | 0.82 | 0.74 - 1.34 |
| Unbleached Kraft | 0.62 | 0.49 - 1.12 |
| Semi-Chemical | 0.65 | 0.69 - 0.86 |
| Unbleached Kraft & Semi-Chemical | 0.49 | 0.41 - 0.66 |
| Dissolving Sulfite Pulp | 0.53 | 0.49 - 0.58 |
| | | |
| Papergrade Sulfite | 0.38 | 0.31 - 0.67 |
| Groundwood Thermo-Mechanical | 0.55 | 0.48 - 0.78 |
| Groundwood-CMN Paper | 0.92 | 0.67 - 2.22 |
| Groundwood-Fine Paper | 0.97 | 0.80 - 2.22 |
| | | |
| Deink | 0.52 | 0.29 - 1.73 |
| Tissue from Wastewater | 1.80 | 0.87 - 4.66 |
| Paperboard from Wastepaper | 1.05 | 0.52 - 4.16 |
| Wastepaper Molded Products | 1.66 | 1.33 - 2.93 |
| Builders' Paper and Roofing Felt | 1.30 | 0.96 - 1.64 |
| | | |
| Nonintegrated Fine | 0.68 | 0.42 - 3.17 |
| Nonintegrated Tissue | 2.67 | 1.93 - 6.17 |
| Nonintegrated Lightweight | 2.54 | 1.52 - 7.82 |
| Nonintegrated Filter and Non-Woven | 3.33 | 2.65 - 5.40 |
| Nonintegrated Paperboard | 9.56 | 8.31 -31.04 |

## TABLE 6A-5. BCT ANALYSIS - Alternative Option 4

| Subcategory | Subcategory Average $/lb | Range |
|---|---|---|
| Dissolving Kraft | 0.31 | 0.29 - 0.35 |
| Market Bleached Kraft | 0.48 | 0.36 - 0.81 |
| BCT Bleached Kraft | 0.44 | 0.30 - 0.83 |
| Alkaline Fine | 0.46 | 0.31 - 0.72 |
| Unbleached Kraft | 0.67 | 0.44 - 2.07 |
| Semi-Chemical | 1.02 | 0.55 - 1.82 |
| Unbleached Kraft & Semi-Chemical | 0.98 | 0.68 - 2.10 |
| Dissolving Sulfite Pulp | 0.43 | 0.26 - 0.70 |
| Papergrade Sulfite | 0.42 | 0.24 - ∞ |
| Groundwood Thermo-Mechanical | 0.62 | 0.60 - 0.62 |
| Groundwood-CMN Paper | 0.65 | 0.54 - 1.57 |
| Groundwood-Fine Paper | 0.75 | 0.62 - 1.59 |
| Deink | 0.68 | 0.43 - 1.75 |
| Tissue from Wastewater | 0.47 | 0.23 - 1.52 |
| Paperboard from Wastepaper | 0.10 | 0.05 - 0.31 |
| Wastepaper Molded Products | 0.64 | 0.53 - 1.04 |
| Builders' Paper and Roofing Felt | 0.43 | 0.31 - 0.54 |
| Nonintegrated Fine | 0.23 | 0.15 - 0.79 |
| Nonintegrated Tissue | 1.56 | 0.81 - 4.31 |
| Nonintegrated Lightweight | 1.44 | 0.52 - 3.87 |
| Nonintegrated Filter and Non-Woven | 1.44 | 0.58 - 3.74 |
| Nonintegrated Paperboard | 3.45 | 0.79 -15.05 |

## Appendix 6-B . Pollution Abatement Capital Expenditures Paper and Allied Products Industry (million $)

| Year | Total | Air | Water | Solid Residues | OSHA Compliance |
|---|---|---|---|---|---|
| 1970 | 187 | 120 | 65 | 2 | |
| 1971 | 202.5 | 134 | 66 | 2.5 | |
| 1972 | 389 | 205 | 129 | 5 | 50 |
| 1973 | 398 | 166 | 161 | 12 | 58 |
| 1974 | 521 | 271 | 193 | 13 | 44 |
| 1975 | 670 | 323 | 266 | 16 | 65 |
| 1976 | 556 | 181 | 279 | 27 | 69 |
| 1977 | 467 | 134 | 262 | 32 | 40 |
| 1978 | 395 | 115 | 181 | 29 | 70 |
| 1979 | 357 | 133 | 124 | 40 | 60 |
| 1980 Planned | 366 | 135 | 125 | 40 | 66 |
| Total | 4,509 | 1,917 | 1,851 | 219 | 522 |
| Total 1971-1978 | 3,599 | 1,529 | 1,537 | 137 | 396 |

Sources: 1970-72: National Council of the Paper Industry for Air and Stream Improvement, Inc. as reported in Pulp & Paper, North America/Profile, June 30, 1979, p. 23;
1973-78: U.S. Bureau of the Census, Current Industrial Reports, Pollution Abatement Cost and Expenditures, 1977 and Advance Report 1978;
1979-80: U.S. Bureau of Economic Analysis; Survey of Current Business, June 1980.

# Section 7

# Economic Impact Analysis

## Introduction

This section presents the results of the economic analysis for the Proposed Regulation and the four Alternative Options which were described in Section 6. Results for the following parts of the analysis are included:

- Base Case Forecast: Variable costs of producers; forecast of price, output and contribution to capital by product sector in 1983-85;
- Costs of Compliance: Average total annual cost per ton and total capital and total annual costs by subcategory and product sector for existing and new sources;
- Demand/Supply: Effects of cost increases on price, output and contribution to capital in each sector;
- Capital Availability: Effect of control costs on present value of new capacity and ability of industry to finance investments in new capacity and pollution control out of current income;
- Mill Closure: Projected mill closures and associated employment impacts;
- Community Impacts: Indirect effects on employment and earnings; and
- Balance of Trade Impacts: Effects of price increases on international competitiveness of products with significant amounts of exports and imports.

### Summary of Results for Proposed Regulation

Under the Proposed Regulation, total costs of compliance for capacity in place by 1983 are:

| | Millions of Dollars (1978) | |
|---|---|---|
| | Capital Costs | Total Annual Costs |
| Existing Sources | 1184.3 | 367.7 |
| New Sources | 174.8 | 62.5 |
| Total | 1359.1 | 430.2 |

This implies an average cost increase of $4.80 per ton for all pulp, paper and paperboard products. These cost increases result in an overall average price increase of $4.10 per ton or 1.02 percent, a decrease in output of 480,000 tons per year or .63 percent, and a decrease in contribution to capital of $49.8 million per year or .42 percent.

Capital availability may be a problem for five sectors in the base case forecast: Bleached Kraft Papers, Bleached Kraft Linerboard, Bleached Kraft Foldinqboard. Newsprint, and Semi-Chemical Corrugating Medium. Under the proposed Regulation, the Unbleached Kraft Linerboard, Uncoated Groundwood, and Bleached Kraft Foldingboard sectors may also have capital availability problems.

Seven mills are predicted to close but another four mills that would have closed under the base case may stay open because revenues rise more than do their treatment costs under the regulations. This leads to an actual net gain of about 600 jobs and a corresponding net increase of $36 million in earnings.

## Base Case Forecast

This section presents a summary of the base case forecast to provide a reference point for the results of the impact analysis given in the following sections. The forecasts presented here are for base variable production costs by subcategory and 1983-85 averages of price, production and contribution to capital from the demand/supply analyses. A description of the base case forecast, including end-use demand growth and capacity expansion, is given in Appendix 7-A and 7-B. See Section 2 for a discussion of the methodology underlying the forecasts.

Information on variable production costs is taken from the 308 Survey. Table 7-1 shows dollar per ton costs for direct dischargers broken down by subcategory and Table 7-2 shows the costs by product sector. Where there is a sufficient number of observations to ensure confidentiality, variable costs are shown separately in each sector or subcategory for mills with low, medium and high variable production costs. For example, mills in a given subcategory are ranked in order of average variable production cost per ton, and then divided into lower, middle and upper thirds. The treatment costs given in the next section are presented for the same groups of mills to show the relative impacts of treatment requirements on the cost structure of the industry.

If there are not enough observations to allow averages for each third to be computed, only an overall average variable cost is shown for a given mill grouping. If there are fewer than five observations in a cell, only an asterisk, "*," is shown to ensure confidentiality.

It is evident that some sectors and subcategories show a much greater range of costs than others. Subcategories with a wide range of costs are Market Bleached Kraft, Papergrade Sulfite, Miscellaneous Integrated, Tissue from Wastepaper, Paperboard from Wastepaper, Nonintegrated Tissue, Nonintegrated Lightweight, and Miscellaneous Nonintegrated. Product Sectors with a wide range of costs are Special Industrial, Thin Papers, Solid Bleached Bristols, Tissues, Recycled Foldingboard, Construction Paper and Board, All Other Board, and Market Pulp.

Table 7-3 shows average values over the forecast period 1983-85 for price, output and contribution to capital (revenue less variable costs) in each product sector. These results were obtained from the demand/supply analyses. The three-year averages are given to be compatible with the results of demand/supply impact analyses given below. Three year averages are given for the impacts because lagged price responses on the demand side mean that it takes up to three years for the full effect of price changes on demand to be felt.

## Direct Impacts - Existing Sources

Tables 7-4 to 7-13 show, by subcategory and product sector, the average annual treatment costs per ton and total capital and annual costs needed for compliance with BCT and BAT regulations under the various treatment options considered. Annual costs include a capital charge based on a capital recovery factor of 22 percent, operation and maintenance costs and energy costs. The average unit costs are for direct dischargers only. The averages in each subcategory and product sector are derived for the same groups of mills whose variable production costs were shown in Tables 7-1 and 7-2. When a mill produces more than one product, costs are allocated across products on an equal per ton basis.

The tables also show total costs of compliance for existing sources through 1983 for both capital costs and total annual costs. Data from the 308 Survey were used to estimate costs of compliance for capacity in place by 1978. The derivation of the forecasts of capacity expansion in each product sector was given in Section 2. It was also

Table 7-1. Average Variable Production Costs of Direct Dischargers by Subcategory: (Averages for Low, Medium, and High Cost Mills) (1978 $/ton)

| Integrated | Low | Medium | High |
|---|---|---|---|
| Dissolving Kraft | | * | |
| Market Bleached Kraft | | 198.7 | |
| BCT Bleached Kraft | | 260.0 | |
| Fine Bleached Kraft & Soda | 304.7 | 402.1 | 575.7 |
| Unbleached Kraft (Linerboard) | 141.0 | 157.6 | 276.2 |
| Unbleached Kraft (Bag) | | 193.6 | |
| Semi-Chemical | 124.1 | 141.2 | 211.7 |
| Unbleached Kraft and Semi-Chem. | | 145.9 | |
| Dissolving Sulfite Pulp | | 292.6 | |
| Papergrade Sulfite | | 504.0 | |
| Groundwood -- Thermo-Mechanical | | * | |
| Groundwood -- Coarse, Molded, Newsp. | | * | |
| Groundwood -- Fine Papers | | 332.3 | |
| Misc. Integrated Mills | 163.1 | 241.2 | 630.1 |
| **Secondary Fiber** | | | |
| Deink (Fine Papers) | | * | |
| Deink (Newsprint)† | | - | |
| Deink (Tissue) | | 413.2 | |
| Tissue from Wastepaper | | 474.7 | |
| Paperboard from Wastepaper | 124.4 | 175.2 | 312.3 |
| Wastepaper Molded Products | | * | |
| Builders Paper & Roofing Felt | | 111.6 | |
| Misc. Secondary Fiber Mills | | 430.1 | |
| **Nonintegrated** | | | |
| Nonintegrated Fine Papers | 416.4 | 546.9 | 682.9 |
| Nonintegrated Tissue Papers | 319.1 | 723.5 | * |
| Nonintegrated Lightweight | | 918.3 | |
| Nonintegrated Filter & Nonwoven | | 1330.2 | |
| Nonintegrated Lightweight -- Electrical Allowance | | * | |
| Nonintegrated Paperboard | | 359.2 | |
| Misc. Nonintegrated Mills | 510.3 | 664.2 | 1110.7 |

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Source: 308 Survey
*Suppressed due to confidentiality.
†No direct dischargers.

Table 7-2: Average Variable Production Costs of Direct Dischargers by Product Sector (Averages for Low, Medium, and High Cost Mills) (1978 $/ton)

| | Low | Medium | High |
|---|---|---|---|
| Paper | | | |
| Unbleached Kraft | 163.8 | 218.4 | 392.3 |
| Bleached Kraft | 256.7 | 366.6 | 644.3 |
| Glassine | | 719.1 | |
| Spec. Industrial | 378.2 | 730.9 | 1444.9 |
| Newsprint | 175.4 | 209.8 | 268.8 |
| Coated Printing | 314.1 | 431.9 | 578.9 |
| Uncoated Freesheet | 329.8 | 434.9 | 589.6 |
| Uncoated Groundwood | 228.2 | 299.6 | 433.4 |
| Thin Papers | | 821.2 | |
| Solid Bl. Bristols | 263.2 | 381.3 | 874.9 |
| Cotton Fibre | | 804.5 | |
| Tissue | 305.9 | 469.8 | 839.7 |
| Board | | | |
| Unbl. Kraft Liner. | 136.0 | 163.8 | 201.0 |
| Bl. Kraft Liner. | | 240.4 | |
| Bl. Kraft Folding | 211.2 | 267.6 | * |
| Semi-Chem Corr. | 113.3 | 135.6 | 170.7 |
| Recycled Liner. | | 151.8 | |
| Recycled Corr. | | 160.0 | |
| Recycled Folding | 131.9 | 190.6 | 352.7 |
| Constr. Papers & Board | 117.4 | 170.3 | 448.5 |
| Molded Pulp | | 379.7 | |
| Solid Bl. Board | 195.1 | 243.6 | 327.2 |
| All Other Board | 107.3 | 185.0 | 386.1 |
| Pulp | | | |
| Dissolving | | 296.4 | |
| Market | 113.6 | 166.6 | 306.3 |

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Source: 308 Survey

*Suppressed due to confidentiality.

necessary to forecast capacity increases by subcategory. Information on this is less reliable. The approach taken was to assume that expansion would come primarily from integrated mill subcategories, and that it would follow the current mix of integrated subcategories in each product sector. As a conservative estimate, all capacity additions after 1978 are assumed to be direct dischargers and hence subject to BCT/BAT costs.

Starting in 1982, capacity increases due to "greenfield" mills or major alterations of existing plants are assumed subject to NSPS requirements. Thus it was necessary to forecast what fraction of new capacity would be classified as a "new source." This was done using information on installation of new machines in API's capacity forecasts and planned capacity increases in existing plants from the 308 Survey. See the following subsection for NSPS costs. The costs for existing sources described in the previous paragraph were applied to the remaining fraction of capacity increases after 1982.

The estimates presented here have a great deal of uncertainty. Therefore, sensitivity analyses are given in Section 8.

To gauge the impact of treatment costs, they should be compared with the base production costs given in Tables 7-1 and 7-2. This gives a picture of the relative impacts of treatment costs within a given mill grouping. It should be used in interpreting the relationship between price impacts and impacts on contribution to capital discussed below. For example, if mills with high unit variable production costs have low treatment costs relative to mills with lower base production costs, the price impacts (which usually are related to the cost changes of high cost mills) will likely be much smaller than the overall impact on contribution to capital.

### Proposed Regulation

Tables 7-4 and 7-5 give average dollar per ton treatment costs by subcategory and product sector for the Proposed Regulation. The overall average cost increase is $4.80 per ton. The largest absolute cost increases occur in the Market Bleached Kraft, BCT Bleached Kraft, Fine Bleached Kraft and Soda, Papergrade Sulfite, Deink (Tissue) and Tissue from Wastepaper subcategories and in the Bleached Kraft Paper, Uncoated Freesheet, Solid Bleached Bristols, Cotton Fibre, Tissue, Bleached Kraft Linerboard, Bleached Kraft Foldingboard, and Market Pulp product sectors. Estimated total capital costs for existing sources are $1184.3 million and total annual costs are $367.7 million.

## Table 7-3: Summary of Base Case Forecast, 1983-85 Average Values

| Paper | Price (1978 \$/ton) | Output ($10^3$ tons/yr) | Contribution to Capital (1978 \$x$10^6$) |
|---|---|---|---|
| Unbleached Kraft | 294 | 4394 | 570 |
| Bleached Kraft | 350 | 624 | 68 |
| Glassine | 873 | 201 | 32 |
| Spec. Industrial | 945 | 572 | 561 |
| Newsprint | 299 | 5814 | 557 |
| Coated Printing | 600 | 5941 | 430 |
| Uncoated Freesheet | 580 | 9054 | 2775 |
| Uncoated Groundwood | 485 | 1720 | 1402 |
| Thin Papers | 672 | 420 | 155 |
| Solid Bl. Bristols | 488 | 1106 | 255 |
| Cotton Fibre | 1480 | 122 | 54 |
| Tissue | 956 | 4933 | 442 |
| **Board** | | | |
| Unbl. Kraft Liner. | 230 | 17042 | 1255 |
| Bl. Kraft Liner. | 267 | 128 | 6 |
| Bl. Kraft Folding | 438 | 2225 | 297 |
| Semi-Chem. Corr. | 220 | 5699 | 438 |
| Recycled Liner | 202 | 555 | 29 |
| Recycled Corr. | 211 | 1489 | 121 |
| Recycled Folding | 358 | 2951 | 296 |
| Constr. Paper & Bd. | 269 | 5745 | 739 |
| Molded Pulp† | - | - | - |
| Solid Bl. Board | 464 | 2028 | 409 |
| All Other Board | 297 | 4710 | 905 |
| **Pulp** | | | |
| Dissolving | 355 | 1413 | 110 |
| Market† | - | - | - |

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Source: 308 Survey, Demand/Supply Forecast
†Demand/supply analysis not available.

## Table 7-4. Treatment Costs of Direct Dischargers By Subcategory: Proposed Regulation

| | Unit Total Annual Costs (1978 $/ton) (Averages for Low, Medium and High Cost Mills) | | | Total Costs Millions of 1978 $ | |
|---|---|---|---|---|---|
| **Integrated** | Low | Medium | High | Capital | Total Annual |
| Dissolving Kraft | | * | | * | * |
| Market Bl. Kraft | | 9.2 | | 67.9 | 21.6 |
| BCT Bl. Kraft | | 8.2 | | 85.7 | 25.4 |
| Fine Bl. Kraft & Soda | 10.6 | 6.6 | 9.0 | 159.9 | 49.3 |
| Unbl. Kraft (Linerboard) | 2.8 | 2.3 | 4.6 | 67.4 | 20.5 |
| Unbl. Kraft (Bag) | | 5.8 | | 43.7 | 13.1 |
| Semi-Chemical | 2.1 | 3.7 | 5.3 | 34.4 | 11.5 |
| Unbl. Kraft and Semi-Chem. | | 4.0 | | 73.5 | 21.5 |
| Dissolving Sulfite Pulp | | 0 | | 0 | 0 |
| Papergrade Sulfite | | 15.0 | | 92.5 | 29.1 |
| Groundwood Thermo-Mechanical | | * | | * | * |
| Groundwood Coarse, Molded, Newsprint | | * | | * | * |
| Groundwood -- Fine Papers | | 5.9 | | 28.2 | 9.7 |
| Misc. Integrated Mills | 8.1 | 4.8 | 13.1 | 405.9 | 124.3 |
| **Secondary Fiber** | | | | | |
| Deink (Fine Papers) | | * | | * | * |
| Deink (Newsprint)† | | 0 | | 0 | 0 |
| Deink (Tissue) | | 14.6 | | 21.5 | 7.9 |
| Tissue from Wastepaper | | 13.5 | | 3.6 | 1.4 |
| Paperboard from Wastepaper | 2.1 | 4.6 | 2.0 | 7.3 | 8.3 |
| Wastepaper Molded Products | | * | | * | * |
| Builders Paper & Roofing Felt | | 0 | | 0 | 0 |
| Misc. Secondary Fiber Mills | | 3.8 | | 8.0 | 2.8 |
| **Nonintegrated** | | | | | |
| Nonintegrated Fine Papers | 6.6 | 1.2 | 8.6 | 12.9 | 4.0 |
| Nonintegrated Tissue Papers | 0.9 | 0.9 | * | 1.7 | 0.4 |
| Nonintegrated Lightweight | | 4.3 | | 4.7 | 1.1 |
| Nonintegrated Filter & Non-woven | | 0 | | 0 | 0 |
| Nonintegrated Lightweight -- Electrical Allowance | | 0 | | 0 | 0 |
| Nonintegrated Paperboard | | 0 | | 0 | 0 |
| Misc. Nonintegrated Mills | 4.3 | 4.8 | 6.8 | 10.1 | 2.3 |
| Total | | | | 1184.3 | 367.7 |

Source: Meta Systems estimates.

†No direct dischargers in this subcategory.
*Suppressed due to confidentiality.

## TABLE 7-4A. PERCENT INCREASE IN PRODUCTION COSTS DUE TO TREATMENT REQUIREMENTS BY SUBCATEGORY:

Proposed Regulation

Averages for Low, Medium
and High Cost Mills

| Integrated | Low | Medium | High |
|---|---|---|---|
| Dissolving Kraft | | * | |
| Market Bleached Kraft | | 4.63 | |
| BCT Bleached Kraft | | 3.15 | |
| Fine Bleached Kraft & Soda | 3.47 | 1.64 | 1.56 |
| Unbleached Kraft (Linerboard) | 1.99 | 1.46 | 1.67 |
| Unbleached Kraft (Bag) | | 3.00 | |
| Semi-Chemical | 1.69 | 2.62 | 2.50 |
| Unbleached Kraft and Semi-Chem. | | 2.74 | |
| Dissolving Sulfite Pulp | | 0 | |
| Papergrade Sulfite | | 2.98 | |
| Groundwood -- Thermo-Mechanical | | * | |
| Groundwood -- Coarse, Molded, Newsp. | | * | |
| Groundwood -- Fine Papers | | 1.78 | |
| Misc. Integrated Mills | 4.97 | 1.99 | 2.08 |
| Secondary Fiber | | | |
| Deink (Fine Papers) | | * | |
| Deink (Newsprint) | | 0 | |
| Deink (Tissue) | | 3.53 | |
| Tissue from Wastepaper | | 2.84 | |
| Paperboard from Wastepaper | 1.69 | 2.63 | .64 |
| Wastepaper Molded Products | | * | |
| Builders Paper & Roofing Felt | | 0 | |
| Misc. Secondary Fiber Mills | | .88 | |
| Nonintegrated | | | |
| Nonintegrated Fine Papers | 1.59 | .22 | 1.26 |
| Nonintegrated Tissue Papers | .28 | .12 | * |
| Nonintegrated Lightweight | | .47 | |
| Nonintegrated Filter & Non-woven | | 0 | |
| Nonintegrated Lightweight --Electrical Allowance | | 0 | |
| Nonintegrated Paperboard | | 0 | |
| Misc. Nonintegrated Mills | .84 | .72 | .61 |

Source: Meta Systems estimates
*Suppressed due to confidentiality.

## Table 7-5. Treatment Costs of Direct Dischargers By Product Sector: Proposed Regulation

| | Unit Total Annual Costs (1978 $/ton) (Averages for Low, Medium and High Cost Mills) | | | Total Costs Millions of 1978 $ | |
|---|---|---|---|---|---|
| | Low | Medium | High | Capital | Total Annual |
| Paper | | | | | |
| Unbleached Kraft | 4.1 | 4.5 | 6.5 | 59.7 | 17.9 |
| Bleached Kraft | 8.9 | 8.9 | 4.2 | 25.0 | 7.6 |
| Glassine | | 7.2 | | 6.7 | 2.0 |
| Spec. Industrial | 8.3 | 5.6 | 2.4 | 10.0 | 2.9 |
| Newsprint | 8.4 | 5.2 | 6.6 | 84.4 | 26.1 |
| Coated Printing | 6.3 | 5.8 | 4.8 | 92.0 | 28.4 |
| Uncoated Freesheet | 8.7 | 6.5 | 7.7 | 173.9 | 54.3 |
| Uncoated Groundwood | 4.8 | 6.6 | 7.0 | 27.8 | 8.4 |
| Thin Papers | 5.3 | 2.6 | 8.5 | 12.1 | 4.3 |
| Solid Bl. Bristols | 7.8 | 7.1 | 6.4 | 17.8 | 5.2 |
| Cotton Fibre | | 12.7 | | 3.8 | 1.1 |
| Tissue | 9.8 | 12.7 | 4.2 | 84.5 | 27.0 |
| Board | | | | | |
| Unbl. Kraft Liner. | 3.3 | 3.7 | 4.6 | 163.9 | 49.3 |
| Bl. Kraft Liner. | | 7.0 | | 3.5 | 1.0 |
| Bl. Kraft Folding | 6.9 | 7.6 | * | 52.3 | 15.6 |
| Semi-Chem. Corr. | 3.6 | 3.8 | 6.2 | 57.1 | 18.2 |
| Recycled Liner | | 3.8 | | 2.0 | 0.8 |
| Recycled Corr. | | 2.7 | | 3.2 | 1.4 |
| Recycled Folding | 3.8 | 3.7 | 2.6 | 8.1 | 3.2 |
| Constr. Paper & Bd. | 0.2 | 0.6 | 5.5 | 5.3 | 1.9 |
| Molded Pulp | | 2.2 | | 1.0 | 0.3 |
| Solid Bl. Board | 7.3 | 4.4 | 6.3 | 36.2 | 10.8 |
| All Other Board | 0.4 | 3.2 | 5.1 | 7.0 | 4.3 |
| Pulp | | | | | |
| Dissolving | | 1.8 | | 16.3 | 5.1 |
| Market | 7.9 | 6.7 | 13.8 | 221.3 | 68.8 |
| Total | | | | 1184.3 | 367.7 |

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Source: Meta Systems estimates.

*Suppressed due to confidentiality.

## TABLE 7-5A. PERCENT INCREASE IN PRODUCTION COSTS DUE TO TREATMENT REQUIREMENTS BY PRODUCT SECTOR

Proposed Regulation

Averages for Low, Medium
and High Cost Mills

| Paper | Low | Medium | High |
|---|---|---|---|
| Unbleached Kraft | 2.50 | 2.06 | 1.66 |
| Bleached Kraft | 3.47 | 2.43 | .65 |
| Glassine | | 1.00 | |
| Spec. Industrial | 2.19 | .77 | .17 |
| Newsprint | 4.79 | 2.48 | 2.46 |
| Coated Printing | 2.01 | 1.34 | .83 |
| Uncoated Freesheet | 2.64 | 1.49 | 1.31 |
| Uncoated Groundwood | 2.10 | 2.20 | 1.62 |
| Thin Papers | | .32 | |
| Solid Bl. Bristols | 2.96 | 1.86 | .73 |
| Cotton Fibre | | 1.58 | |
| Tissue | 3.20 | 2.70 | .50 |
| Board | | | |
| Unbl. Kraft Liner. | 2.43 | 2.26 | 2.29 |
| Bl. Kraft Liner. | | 2.91 | |
| Bl. Kraft Folding | 3.27 | 2.84 | * |
| Semi-Chem. Corr. | 3.18 | 2.80 | 3.63 |
| Recycled Liner | | 2.50 | |
| Recycled Corr. | | 1.69 | |
| Recycled Folding | 2.88 | 1.94 | .74 |
| Constr. Paper & Bd. | .17 | .35 | 1.23 |
| Molded Pulp | | .58 | |
| Solid Bl. Board | 3.74 | 1.81 | 1.93 |
| All Other Board | .37 | 1.73 | 1.32 |
| Pulp | | | |
| Dissolving | | .61 | |
| Market | 6.95 | 4.02 | 4.51 |

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Source: Meta Systems estimates.
*Suppressed due to confidentiality.

Tables 7-4a and 7-5a show the percent increases over base production costs in Table 7-1 and 7-2 represented by the unit treatment cost estimates in Tables 7-4 and 7-5. Subcategories with the highest percent cost increases are Market Bleached Kraft, BCT Bleached Kraft, Fine Bleached Kraft and Soda, Papergrade Sulfite, Miscellaneous Integrated Mills, and Deink (Tissue). Product sectors with the highest percent cost increases are Bleached Kraft Papers, Newsprint, Tissue, Bleached Kraft Foldingboard, Semi-Chemical Corrugating Medium, Solid Bleached Board, and Market Pulp.

Tables 7-4 and 7-5 show that in general the variability of unit treatment costs is greater over product sectors than subcategories. This is because most product sectors include integrated, secondary fiber and nonintegrated mills, and the latter two tend to have lower treatment costs than the former. In sectors such as Bleached Kraft Paper, Special Industrial Paper and Tissue, low-cost producers face the highest treatment costs. Sectors where high cost producers bear the highest treatment costs are Thin Papers, Semi-Chemical Corrugating Medium, Construction Paper and Board, and All Other Board. As will be seen in the demand/supply analysis, the distribution of costs across producers in the same product sector has an important effect on the resulting changes in price and contribution to capital.

### Alternative Option 1

Tables 7-6 and 7-7 show treatment cost estimates by subcategory and product sector for Alternative Option 1. The average cost increase is $2.80 per ton. The total capital costs are $731.4 million and total annual costs are $218.5 million. The subcategories with the highest absolute cost increases are Fine Bleached Kraft and Soda, Dissolving Sulfite Pulp, Papergrade Sulfite, Tissue from Wastepaper, and Nonintegrated Lightweight. Product sectors with the highest absolute increases are Glassine and Greaseproof, Special Industrial, Coated Printing, Uncoated Freesheet, Thin Papers, Tissue, Molded Pulp, and Dissolving Pulp.

Tables 7-6a and 7-7a show the corresponding percentage increases in average unit costs over base production costs given in Tables 7-1 and 7-2. Subcategories with the highest percent cost increases are Market Bleached Kraft, Fine Bleached Kraft and Soda, Semi-Chemical, Dissolving Sulfite Pulp, and Tissue from Wastepaper. Product sectors with the highest percent cost increases are Newsprint, Tissue, Semi-Chemical Corrugating Medium, Construction Paper and Board, Solid Bleached Board, Dissolving Pulp, and Market Pulp.

Table 7-6. Average Total Annual Treatment Costs of Direct Dischargers by Subcategory: Alternative Option 1

| | Unit Total Annual Costs (1978 $/ton) (Averages for Low, Medium and High Cost Mills) | | | Total Costs Millions of 1978 $ | |
|---|---|---|---|---|---|
| Integrated | Low | Medium | High | Capital | Total Annual |
| Dissolving Kraft | | * | | * | * |
| Market Bleached Kraft | | 3.9 | | 23.1 | 9.4 |
| BCT Bleached Kraft | | 3.9 | | 35.1 | 12.9 |
| Fine Bleached Kraft & Soda | 6.3 | 6.9 | 7.7 | 131.8 | 34.8 |
| Unbleached Kraft (Linerboard) | 1.2 | 1.3 | 1.5 | 30.4 | 9.9 |
| Unbleached Kraft (Bag) | | 1.4 | | 13.3 | 3.7 |
| Semi-Chemical | 3.3 | 3.2 | 3.3 | 34.1 | 9.7 |
| Unbleached Kraft and Semi-Chem. | | 1.5 | | 32.6 | 8.9 |
| Dissolving Sulfite Pulp | | 23.2 | | 101.9 | 31.0 |
| Papergrade Sulfite | | 7.6 | | 61.4 | 15.6 |
| Groundwood -- Thermo-Mechanical | | * | | * | * |
| Groundwood -- Coarse, Molded, Newsp. | | * | | * | * |
| Groundwood -- Fine Papers | | 3.6 | | 31.7 | 5.6 |
| Misc. Integrated Mills | 2.6 | 3.1 | 2.6 | 177.5 | 56.6 |
| Secondary Fiber | | | | | |
| Deink (Fine Papers) | | * | | * | * |
| Deink (Newsprint)† | | - | | 0 | 0 |
| Deink (Tissue) | | 2.8 | | 5.0 | 1.2 |
| Tissue from Wastepaper | | 8.2 | | 3.0 | 1.0 |
| Paperboard from Wastepaper | 0.6 | 0.6 | 0.7 | 5.4 | 1.7 |
| Wastepaper Molded Products | | * | | * | * |
| Builders Paper & Roofing Felt | | 4.8 | | 3.4 | 1.0 |
| Misc. Secondary Fiber Mills | | 1.6 | | 4.1 | 0.9 |
| Nonintegrated | | | | | |
| Nonintegrated Fine Papers | 3.5 | 3.8 | 5.2 | 14.7 | 4.1 |
| Nonintegrated Tissue Papers | 2.3 | 2.0 | * | 3.8 | 0.9 |
| Nonintegrated Lightweight | | 6.9 | | 4.2 | 1.2 |
| Nonintegrated Filter & Nonwoven | | 3.5 | | 1.0 | 0.3 |
| Nonintegrated Lightweight -- Electrical Allowance | | * | | * | * |
| Nonintegrated Paperboard | | 0 | | 0 | 0 |
| Misc. Nonintegrated Mills | 3.1 | 3.8 | 5.2 | 16.2 | 1.8 |
| Total | | | | 731.4 | 218.5 |

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Source: Meta Systems estimates
*Suppressed due to confidentiality.
†No direct dischargers.

## TABLE 7-6A. PERCENT INCREASE IN PRODUCTION COSTS DUE TO TREATMENT REQUIREMENTS BY SUBCATEGORY:

### Alternative Option 1

### Averages for Low, Medium and High Cost Mills

| | Low | Medium | High |
|---|---|---|---|
| Integrated | | | |
| Dissolving Kraft | | * | |
| Market Bleached Kraft | | 1.96 | |
| BCT Bleached Kraft | | 1.50 | |
| Fine Bleached Kraft & Soda | 2.07 | 1.72 | 1.34 |
| Unbleached Kraft (Linerboard) | .85 | .82 | .54 |
| Unbleached Kraft (Bag) | | .72 | |
| Semi-Chemical | 2.66 | 2.27 | 1.56 |
| Unbleached Kraft and Semi-Chem. | | 1.03 | |
| Dissolving Sulfite Pulp | | 7.93 | |
| Papergrade Sulfite | | 1.51 | |
| Groundwood -- Thermo-Mechanical | | * | |
| Groundwood -- Coarse, Molded, Newsp. | | * | |
| Groundwood -- Fine Papers | | 1.08 | |
| Misc. Integrated Mills | 1.59 | 1.29 | .41 |
| Secondary Fiber | | | |
| Deink (Fine Papers) | | * | |
| Deink (Newsprint) | | -- | |
| Deink (Tissue) | | .68 | |
| Tissue from Wastepaper | | 1.73 | |
| Paperboard from Wastepaper | .48 | .34 | .22 |
| Wastepaper Molded Products | | * | |
| Builders Paper & Roofing Felt | | 4.30 | |
| Misc. Secondary Fiber Mills | | .37 | |
| Nonintegrated | | | |
| Nonintegrated Fine Papers | .84 | .69 | .76 |
| Nonintegrated Tissue Papers | .72 | .28 | * |
| Nonintegrated Lightweight | | .75 | |
| Nonintegrated Filter & Non-woven | | .26 | |
| Nonintegrated Lightweight -- Electrical Allowance | | * | |
| Nonintegrated Paperboard | | 0 | |
| Misc. Nonintegrated Mills | .61 | .57 | .47 |

Source: Meta Systems estimates
*Suppressed due to confidentiality.

## Table 7-7. **Total Annual Treatment Costs of Direct Dischargers by Product Sector and Total Cost of Compliance Through 1983: Alternative** Option 1

| | Unit Total Annual Costs (1978 $/ton) (Averages for Low, Medium and High Cost Mills) | | | Total Costs Millions of 1978 $ | |
|---|---|---|---|---|---|
| | Low | Medium | High | Capital | Total Annual |
| Paper | | | | | |
| Unbleached Kraft | 1.6 | 2.6 | 2.7 | 20.2 | 6.4 |
| Bleached Kraft | 3.4 | 3.4 | 2.4 | 9.8 | 3.0 |
| Glassine | | 4.4 | | 4.7 | 1.2 |
| Spec. Industrial | 4.4 | 4.3 | 4.2 | 8.1 | 2.1 |
| Newsprint | 3.4 | 2.7 | 2.4 | 45.3 | 13.3 |
| Coated Printing | 3.5 | 4.9 | 4.1 | 67.0 | 17.4 |
| Uncoated Freesheet | 4.9 | 4.5 | 4.6 | 119.6 | 33.0 |
| Uncoated Groundwood | 2.9 | 3.0 | 3.1 | 15.6 | 3.9 |
| Thin Papers | | 7.2 | | 6.0 | 1.6 |
| Solid Bl. Bristols | 3.9 | 5.2 | 3.2 | 7.0 | 3.2 |
| Cotton Fibre | | 4.0 | | 0.6 | 0.2 |
| Tissue | 4.9 | 4.1 | 2.9 | 45.6 | 13.3 |
| Board | | | | | |
| Unbl. Kraft Liner. | 1.5 | 1.6 | 1.7 | 72.1 | 21.5 |
| Bl. Kraft Liner. | | 2.8 | | 1.1 | 0.4 |
| Bl. Kraft Folding | 3.1 | 3.1 | * | 21.1 | 7.7 |
| Semi-Chem Corr. | 2.2 | 3.2 | 3.5 | 46.7 | 13.3 |
| Recycled Liner. | | 0.5 | | 1.0 | 0.3 |
| Recycled Corr. | | 1.2 | | 2.5 | 0.7 |
| Recycled Folding | 1.2 | 0.5 | 1.3 | 2.4 | 0.7 |
| Constr. Paper & Bd. | 2.5 | 0.6 | 2.6 | 7.3 | 2.2 |
| Molded Pulp | | 5.4 | | 2.8 | 0.7 |
| Solid Bl. Board | 3.3 | 3.4 | 3.6 | 18.6 | 6.4 |
| All Other Board | 1.4 | 1.4 | 2.1 | 5.7 | 1.6 |
| Pulp | | | | | |
| Dissolving | | 17.1 | | 88.5 | 27.6 |
| Market | 3.0 | 4.2 | 3.7 | 111.2 | 36.8 |
| Total | | | | 731.4 | 218.5 |

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Source: Meta Systems estimates
*Suppressed due to confidentiality.

## TABLE 7-7A. PERCENT INCREASE IN PRODUCTION COSTS DUE TO TREATMENT REQUIREMENTS BY PRODUCT SECTOR

### Alternative Option 1

| | Averages for Low, Medium and High Cost Mills | | |
|---|---|---|---|
| | Low | Medium | High |
| **Paper** | | | |
| Unbleached Kraft | .98 | 1.19 | .69 |
| Bleached Kraft | 1.32 | .93 | .37 |
| Glassine | | .61 | |
| Spec. Industrial | 1.16 | .59 | .29 |
| Newsprint | 1.94 | 1.29 | .89 |
| Coated Printing | 1.11 | 1.13 | .71 |
| Uncoated Freesheet | 1.49 | 1.03 | .78 |
| Uncoated Groundwood | 1.27 | 1.00 | .72 |
| Thin Papers | | .88 | |
| Solid Bl. Bristols | 1.48 | 1.36 | .37 |
| Cotton Fiber | | .50 | |
| Tissue | 1.60 | .87 | .35 |
| **Board** | | | |
| Unbl. Kraft Liner. | 1.10 | .98 | .85 |
| Bl. Kraft Liner. | | 1.16 | * |
| Bl. Kraft Folding | 1.47 | 1.16 | 2.05 |
| Semi-Chem. Corr. | 1.94 | 2.36 | |
| Recycled Liner | | .33 | |
| Recycled Corr. | | .75 | |
| Recycled Folding | .91 | .26 | .37 |
| Constr. Paper & Bd. | 2.13 | .35 | .58 |
| Molded Pulp | | 1.42 | |
| Solid Bl. Board | 1.69 | 1.40 | 1.10 |
| All Other Board | 1.30 | .76 | .54 |
| **Pulp** | | | |
| Dissolving | | 5.77 | |
| Market | 2.64 | 2.52 | 1.21 |

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Source: Meta Systems estimates.
*Suppressed due to confidentiality.

## Alternative Option 2

Tables 7-8 and 7-9 show treatment cost estimates by subcategory and product sector for Alternative Option 2. The average cost increase is $9.30 per ton. The total capital costs are $1555.8 million and the total annual costs are $707.5 million. The subcategories with the highest absolute cost increases are Market Bleached Kraft, Fine Bleached Kraft and Soda, Dissolving Sulfite Pulp, Papergrade Sulfite, and Deink (Tissue). The product sectors with the highest absolute increases are Coated Printing, Uncoated Freesheet, Solid Bleached Bristols, Tissue, Bleached Kraft Foldingboard, Dissolving Pulp and Market Pulp.

Tables 7-8a and 7-9a show the corresponding percentage increases in average unit cost over base production costs given in Tables 7-1 and 7-2. Subcategories with the highest percent cost increases are Market Bleached Kraft, BCT Bleached Kraft, Fine Bleached Kraft and Soda, Semi-Chemical, Unbleached Kraft and Semi-Chemical, Dissolving Sulfite Pulp, Papergrade Sulfite, and Deink (Tissue). Product sectors with the highest percent cost increases are Newsprint, Uncoated Groundwood, Unbleached Kraft Linerboard, Semi-Chemical Corrugating Medium, Solid Bleached Board, Dissolving Pulp and Market Pulp.

## Alternative Option 3

Tables 7-10 and 7-11 show treatment cost estimates by subcategory and product sector for Alternative Option 3. The average cost increase is $11.20 per ton. Total capital costs are $2115.6 million and total annual costs are $856.3 million. The subcategories with the highest absolute cost increases are primarily those of integrated mills, i.e. Market Bleached Kraft, BCT Bleached Kraft, Fine Bleached Kraft and Soda, Dissolving Sulfite Pulp, Papergrade Sulfite, and Deink (Tissue). Product sectors showing the greatest increases are Coated Printing, Uncoated Freesheet, Solid Bleached Bristols, Tissue, Bleached Kraft Linerboard, Bleached Kraft Foldingboard, Solid Bleached Board, Dissolving Pulp and Market Pulp. The impacts are substantially higher than in the Proposed Regulation.

Tables 7-10a and 7-11a show the corresponding percentage increases in unit average costs over base production costs given in Tables 7-1 and 7-2. Subcategories with the highest percent cost increases are Market Bleached Kraft, BCT Bleached Kraft, Fine Bleached Kraft and Soda, Semi-Chemical, Dissolving Sulfite Pulp, and Papergrade Sulfite. Product sectors with the highest percent cost increases are Newsprint, Solid Bleached Bristols, Tissue, Unbleached Kraft Linerboard, Bleached Kraft Linerboard, Semi-Chemical Corrugating Medium, Solid Bleached Board, Dissolving Pulp and Market Pulp.

### Table 7-8. Average Total Annual Treatment Costs of Direct Dischargers by Subcategory: Alternative Option 2

| | Unit Total Annual Costs (1978 $/ton) (Averages for Low, Medium and High Cost Mills) | | | Total Costs Millions of 1978 $ | |
|---|---|---|---|---|---|
| **Integrated** | Low | Medium | High | Capital | Total Annual |
| Dissolving Kraft | | * | | * | * |
| Market Bleached Kraft | | 19.7 | | 86.2 | 44.6 |
| BCT Bleached Kraft | | 16.4 | | 99.3 | 53.7 |
| Fine Bleached Kraft & Soda | 15.1 | 16.2 | 19.4 | 165.5 | 82.7 |
| Unbleached Kraft (Linerboard) | 6.4 | 7.6 | 9.3 | 114.0 | 51.8 |
| Unbleached Kraft (Bag) | | 7.7 | | 56.3 | 23.7 |
| Semi-Chemical | 8.8 | 8.1 | 9.1 | 55.7 | 24.5 |
| Unbleached Kraft and Semi-Chem. | | 7.2 | | 81.3 | 43.4 |
| Dissolving Sulfite Pulp | | 30.6 | | 65.7 | 36.9 |
| Papergrade Sulfite | | 29.4 | | 115.8 | 60.2 |
| Groundwood -- Thermo-Mechanical | | * | | * | * |
| Groundwood -- Coarse, Molded, Newsp. | | * | | * | * |
| Groundwood -- Fine Papers | | 8.5 | | 41.8 | 15.0 |
| Misc. Integrated Mills | 11.4 | 10.8 | 9.1 | 486.9 | 207.7 |
| **Secondary Fiber** | | | | | |
| Deink (Fine Papers) | | * | | * | * |
| Deink (Newsprint)† | | - | | 0 | 0 |
| Deink (Tissue) | | 22.3 | | 7.5 | 12.3 |
| Tissue from Wastepaper | | 8.2 | | 3.0 | 1.0 |
| Paperboard from Wastepaper | 0.6 | 1.3 | 0.7 | 13.5 | 4.0 |
| Wastepaper Molded Products | | * | | * | * |
| Builders Paper & Roofing Felt | | 4.8 | | 3.4 | 1.0 |
| Misc. Secondary Fiber Mills | | 12.8 | | 24.0 | 8.1 |
| **Nonintegrated** | | | | | |
| Nonintegrated Fine Papers | 9.8 | 9.0 | 7.0 | 33.1 | 14.4 |
| Nonintegrated Tissue Papers | 2.3 | 2.0 | * | 3.8 | 0.9 |
| Nonintegrated Lightweight | | 6.9 | | 4.3 | 1.2 |
| Nonintegrated Filter & Nonwoven | | 3.5 | | 1.0 | 0.3 |
| Nonintegrated Lightweight -- Electrical Allowance | | * | | * | * |
| Nonintegrated Paperboard | | 0 | | 0 | 0 |
| Misc. Nonintegrated Mills | 5.4 | 6.4 | 2.6 | 17.7 | 2.7 |
| **Total** | | | | 1555.8 | 707.5 |

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Source: Meta Systems estimates
*Suppressed due to confidentiality.
†No direct dischargers.

## TABLE 7-8A. PERCENT INCREASE IN PRODUCTION COSTS DUE TO TREATMENT REQUIREMENTS BY SUBCATEGORY:

### Alternative Option 2

Averages for Low, Medium
and High Cost Mills

| Integrated | Low | Medium | High |
|---|---|---|---|
| Dissolving Kraft | | * | |
| Market Bleached Kraft | | 9.91 | |
| BCT Bleached Kraft | | 6.31 | |
| Fine Bleached Kraft & Soda | 4.96 | 4.03 | 3.37 |
| Unbleached Kraft (Linerboard) | 4.54 | 4.82 | 3.37 |
| Unbleached Kraft (Bag) | | 3.98 | |
| Semi-Chemical | 7.09 | 5.74 | 4.30 |
| Unbleached Kraft and Semi-Chem. | | 4.93 | |
| Dissolving Sulfite Pulp | | 10.46 | |
| Papergrade Sulfite | | 5.83 | |
| Groundwood -- Thermo-Mechanical | | * | |
| Groundwood -- Coarse, Molded, Newsp. | | * | |
| Groundwood -- Fine Papers | | 2.56 | |
| Misc. Integrated Mills | 2.58 | 2.49 | .97 |
| **Secondary Fiber** | | | |
| Deink (Fine Papers) | | * | |
| Deink (Newsprint) | | -- | |
| Deink (Tissue) | | 5.40 | |
| Tissue from Wastepaper | | 1.73 | |
| Paperboard from Wastepaper | .48 | .74 | .22 |
| Wastepaper Molded Products | | * | |
| Builders Paper & Roofing Felt | | 4.30 | |
| Misc. Secondary Fiber Mills | | 2.98 | |
| **Nonintegrated** | | | |
| Nonintegrated Fine Papers | 2.35 | 1.65 | 1.03 |
| Nonintegrated Tissue Papers | .72 | .28 | * |
| Nonintegrated Lightweight | | .75 | |
| Nonintegrated Filter & Non-woven | | .26 | |
| Nonintegrated Lightweight -- Electrical Allowance | | * | |
| Nonintegrated Paperboard | | 0 | |
| Misc. Nonintegrated Mills | 1.06 | .96 | .23 |

Source: Meta Systems estimates
*Suppressed due to confidentiality.

Table 7-9: Total Annual Treatment Costs of Direct Dischargers by Product Sector and Total Cost of Compliance Through 1983: Alternative Option 2

|  | Unit Total Annual Costs (1978 $/ton) (Averages for Low, Medium and High Cost Mills) |  |  | Total Costs Millions of 1978 $ |  |
|---|---|---|---|---|---|
| **Paper** | Low | Medium | High | Capital | Total Annual |
| Unbleached Kraft | 5.4 | 4.5 | 7.4 | 67.5 | 29.6 |
| Bleached Kraft | 4.9 | 5.8 | 6.9 | 26.1 | 11.1 |
| Glassine |  | 9.2 |  | 9.8 | 4.2 |
| Spec. Industrial | 10.9 | 5.2 | 4.4 | 14.7 | 5.3 |
| Newsprint | 7.6 | 7.8 | 5.3 | 131.0 | 57.3 |
| Coated Printing | 9.5 | 11.6 | 12.7 | 111.4 | 49.0 |
| Uncoated Freesheet | 10.2 | 15.0 | 11.6 | 211.4 | 85.6 |
| Uncoated Groundwood | 9.3 | 6.6 | 10.7 | 38.1 | 15.6 |
| Thin Papers |  | 9.1 |  | 15.8 | 5.4 |
| Solid Bl. Bristols | 10.5 | 14.9 | 6.1 | 21.2 | 10.0 |
| Cotton Fibre |  | 4.0 |  | 0.8 | 0.3 |
| Tissue | 12.0 | 12.8 | 6.7 | 111.4 | 48.7 |
| **Board** |  |  |  |  |  |
| Unbl. Kraft Liner. | 6.7 | 6.0 | 5.4 | 224.3 | 100.4 |
| Bl. Kraft Liner. |  | 8.3 |  | 2.8 | 1.5 |
| Bl. Kraft Folding | 7.6 | 12.3 | * | 67.1 | 32.4 |
| Semi-Chem Corr. | 7.3 | 6.8 | 9.1 | 87.3 | 39.5 |
| Recycled Liner. |  | 1.9 |  | 3.8 | 1.3 |
| Recycled Corr. |  | 4.1 |  | 6.0 | 2.4 |
| Recycled Folding | 2.2 | 1.3 | 5.2 | 5.2 | 2.0 |
| Constr. Paper & Bd. | 2.5 | 0.6 | 4.7 | 19.5 | 6.9 |
| Molded Pulp |  | 1.6 |  | 2.8 | 0.7 |
| Solid Bl. Board | 9.0 | 6.5 | 9.5 | 48.2 | 23.4 |
| All Other Board | 1.9 | 2.7 | 6.6 | 15.3 | 6.3 |
| **Pulp** |  |  |  |  |  |
| Dissolving |  | 26.4 |  | 75.6 | 42.4 |
| Market | 8.7 | 12.4 | 19.0 | 235.6 | 114.6 |
| **Total** |  |  |  | 1555.8 | 707.5 |

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Source: Meta Systems estimates

*Suppressed due to confidentiality.

## TABLE 7-9A. PERCENT INCREASE IN PRODUCTION COSTS DUE TO TREATMENT REQUIREMENTS BY PRODUCT SECTOR:

### Alternative Option 2

Averages for Low, Medium
and High Cost Mills

| Paper | Low | Medium | High |
|---|---|---|---|
| Unbleached Kraft | 3.30 | 2.06 | 1.89 |
| Bleached Kraft | 1.91 | 1.58 | 1.07 |
| Glassine |  | 1.28 |  |
| Spec. Industrial | 2.88 | .71 | .30 |
| Newsprint | 4.33 | 3.72 | 1.97 |
| Coated Printing | 3.02 | 2.69 | 2.19 |
| Uncoated Freesheet | 3.09 | 3.45 | 1.97 |
| Uncoated Groundwood | 4.08 | 2.20 | 2.47 |
| Thin Papers |  | 1.11 |  |
| Solid Bl. Bristols | 3.99 | 3.91 | .70 |
| Cotton Fibre |  | .50 |  |
| Tissue | 3.92 | 2.72 | .80 |
| **Board** |  |  |  |
| Unbl. Kraft Liner. | 4.93 | 3.66 | 2.69 |
| Bl. Kraft Liner. |  | 3.45 |  |
| Bl. Kraft Folding | 3.60 | 4.60 | * |
| Semi-Chem. Corr. | 6.44 | 5.01 | 5.33 |
| Recycled Liner |  | 1.25 |  |
| Recycled Corr. |  | 2.56 |  |
| Recycled Folding | 1.67 | .68 | 1.47 |
| Constr. Paper & Bd. | 2.13 | .35 | 1.05 |
| Molded Pulp |  | .42 |  |
| Solid Bl. Board | 4.61 | 2.67 | 2.90 |
| All Other Board | .62 | 1.46 | 1.71 |
| **Pulp** |  |  |  |
| Dissolving |  | 8.91 |  |
| Market | 7.66 | 7.44 | 6.20 |

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Source: Meta Systems estimates.
*Suppressed due to confidentiality.

### Table 7-10. Average Total Annual Treatment Costs of Direct Dischargers by Subcategory: Alternative Option 3

| | Unit Total Annual Costs (1978 $/ton) (Averages for Low, Medium and High Cost Mills) | | | Total Costs Millions of 1978 $ | |
|---|---|---|---|---|---|
| **Integrated** | Low | Medium | High | Capital | Total Annual |
| Dissolving Kraft | | * | | * | * |
| Market Bleached Kraft | | 21.9 | | 105.0 | 49.5 |
| BCT Bleached Kraft | | 49.5 | | 125.0 | 67.9 |
| Fine Bleached Kraft & Soda | 20.0 | 21.7 | 24.1 | 290.5 | 109.2 |
| Unbleached Kraft (Linerboard) | 6.5 | 7.7 | 9.4 | 126.1 | 52.7 |
| Unbleached Kraft (Bag) | | 8.6 | | 47.1 | 19.4 |
| Semi-Chemical | 10.3 | 9.5 | 10.6 | 80.5 | 28.9 |
| Unbleached Kraft and Semi-Chem. | | 7.6 | | 96.0 | 42.2 |
| Dissolving Sulfite Pulp | | 54.6 | | 167.9 | 65.7 |
| Papergrade Sulfite | | 31.8 | | 158.5 | 64.3 |
| Groundwood -- Thermo-Mechanical | | * | | * | * |
| Groundwood -- Coarse, Molded, Newsp. | | * | | * | * |
| Groundwood -- Fine Papers | | 11.0 | | 54.2 | 17.4 |
| Misc. Integrated Mills | 12.9 | 12.6 | 10.3 | 612.3 | 239.8 |
| **Secondary Fiber** | | | | | |
| Deink (Fine Papers) | | * | | * | * |
| Deink (Newsprint)† | | - | | 0 | 0 |
| Deink (Tissue) | | 21.8 | | 28.9 | 11.7 |
| Tissue from Wastepaper | | 8.2 | | 3.0 | 1.0 |
| Paperboard from Wastepaper | 4.5 | 4.0 | 1.6 | 38.4 | 14.9 |
| Wastepaper Molded Products | | * | | * | * |
| Builders Paper & Roofing Felt | | 4.8 | | 3.4 | 1.0 |
| Misc. Secondary Fiber Mills | | 12.2 | | 25.1 | 17.8 |
| **Nonintegrated** | | | | | |
| Nonintegrated Fine Papers | 10.1 | 15.0 | 7.0 | 41.4 | 16.0 |
| Nonintegrated Tissue Papers | 2.3 | 2.0 | * | 3.8 | 0.9 |
| Nonintegrated Lightweight | | 9.5 | | 8.9 | 4.4 |
| Nonintegrated Filter & Nonwoven | | 3.5 | | 1.0 | 0.3 |
| Nonintegrated Lightweight -- Electrical Allowance | | * | | * | * |
| Nonintegrated Paperboard | | 0.0 | | 0 | 0 |
| Misc. Nonintegrated Mills | 8.4 | 6.5 | 5.2 | 17.7 | 5.3 |
| **Total** | | | | 2115.6 | 856.3 |

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Source: Meta Systems estimates.
*Suppressed due to confidentiality.
†No direct dischargers.

## TABLE 7-10A. PERCENT INCREASE IN PRODUCTION COSTS DUE TO TREATMENT REQUIREMENTS BY SUBCATEGORY:

### Alternative Option 3

**Averages for Low, Medium and High Cost Mills**

| Integrated | Low | Medium | High |
|---|---|---|---|
| Dissolving Kraft | | * | |
| Market Bleached Kraft | | 11.02 | |
| BCT Bleached Kraft | | 19.04 | |
| Fine Bleached Kraft & Soda | 6.56 | 5.40 | 4.19 |
| Unbleached Kraft (Linerboard) | 4.61 | 4.89 | 3.40 |
| Unbleached Kraft (Bag) | | 4.44 | |
| Semi-Chemical | 8.30 | 6.73 | 5.01 |
| Unbleached Kraft and Semi-Chem. | | 5.21 | |
| Dissolving Sulfite Pulp | | 18.66 | |
| Papergrade Sulfite | | 6.31 | |
| Groundwood -- Thermo-Mechanical | | * | |
| Groundwood -- Coarse, Molded, Newsp. | | * | |
| Groundwood -- Fine Papers | | 3.31 | |
| Misc. Integrated Mills | 3.86 | 3.52 | 1.16 |
| Secondary Fiber | | | |
| Deink (Fine Papers) | | * | |
| Deink (Newsprint) | | -- | |
| Deink (Tissue) | | 5.28 | |
| Tissue from Wastepaper | | 1.73 | |
| Paperboard from Wastepaper | 3.62 | 2.28 | .51 |
| Wastepaper Molded Products | | * | |
| Builders Paper & Roofing Felt | | 4.30 | |
| Misc. Secondary Fiber Mills | | 2.84 | |
| Nonintegrated | | | |
| Nonintegrated Fine Papers | 2.43 | 2.74 | 1.03 |
| Nonintegrated Tissue Papers | .72 | .28 | * |
| Nonintegrated Lightweight | | 1.03 | |
| Nonintegrated Filter & Non-woven | | .26 | |
| Nonintegrated Lightweight -- Electrical Allowance | | * | |
| Nonintegrated Paperboard | | 0 | |
| Misc. Nonintegrated Mills | 1.65 | .98 | .47 |

Source: Meta Systems estimates

*Suppressed due to confidentiality.

Table 7-11. Total Annual Treatment Costs of Direct Dischargers by Product Sector and Total Cost of Compliance Through 1983: Alternative Option 3

| | Unit Total Annual Costs (1978 $/ton) (Averages for Low, Medium and High Cost Mills) | | | Total Costs Millions of 1978 $ | |
|---|---|---|---|---|---|
| **Paper** | Low | Medium | High | Capital | Total Annual |
| Unbleached Kraft | 6.4 | 6.2 | 8.5 | 81.9 | 33.4 |
| Bleached Kraft | 7.4 | 7.9 | 7.4 | 33.4 | 13.3 |
| Glassine | | 10.4 | | 12.7 | 4.7 |
| Spec. Industrial | 13.1 | 6.0 | 5.7 | 18.2 | 6.2 |
| Newsprint | 9.9 | 9.5 | 7.1 | 139.0 | 61.0 |
| Coated Printing | 11.8 | 15.2 | 16.3 | 159.1 | 59.4 |
| Uncoated Freesheet | 13.1 | 18.0 | 15.6 | 302.5 | 122.6 |
| Uncoated Groundwood | 10.8 | 7.8 | 11.2 | 44.9 | 16.2 |
| Thin Papers | | 11.6 | | 26.2 | 8.3 |
| Solid Bl. Bristols | 26.3 | 22.1 | 7.7 | 29.4 | 11.6 |
| Cotton Fibre | | 7.0 | | 0.8 | 0.3 |
| Tissue | 19.8 | 13.3 | 7.2 | 131.3 | 50.6 |
| **Board** | | | | | |
| Unbl. Kraft Liner. | 7.2 | 6.9 | 6.3 | 289.6 | 114.3 |
| Bl. Kraft Liner. | | 19.2 | | 3.6 | 1.6 |
| Bl. Kraft Folding | 21.8 | 30.0 | * | 84.8 | 35.2 |
| Semi-Chem Corr. | 8.2 | 8.7 | 11.2 | 120.5 | 45.5 |
| Recycled Liner. | | 4.7 | | 8.1 | 3.0 |
| Recycled Corr. | | 6.7 | | 12.2 | 4.9 |
| Recycled Folding | 3.8 | 3.7 | 6.2 | 15.4 | 5.8 |
| Constr. Paper & Bd. | 4.2 | 2.9 | 9.4 | 25.4 | 8.9 |
| Molded Pulp | | 10.0 | | 4.4 | 1.3 |
| Solid Bl. Board | 21.1 | 17.6 | 25.5 | 61.3 | 25.4 |
| All Other Board | 4.5 | 3.4 | 8.1 | 24.2 | 9.5 |
| **Pulp** | | | | | |
| Dissolving | | 43.7 | | 163.7 | 67.4 |
| Market | 16.9 | 17.9 | 29.2 | 318.8 | 143.4 |
| **Total** | | | | 2115.6 | 856.3 |

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Source: Meta Systems estimates

*Suppressed due to confidentiality.

## TABLE 7-11A. PERCENT INCREASE IN PRODUCTION COSTS DUE TO TREATMENT REQUIREMENTS BY PRODUCT SECTOR:

### Alternative Option 3

### Averages for Low, Medium and High Cost Mills

| Paper | Low | Medium | High |
|---|---|---|---|
| Unbleached Kraft | 3.91 | 2.84 | 2.17 |
| Bleached Kraft | 2.88 | 2.15 | 1.15 |
| Glassine | | 1.45 | |
| Spec. Industrial | 3.46 | .82 | .39 |
| Newsprint | 5.64 | 4.53 | 2.64 |
| Coated Printing | 3.76 | 3.52 | 2.82 |
| Uncoated Freesheet | 3.97 | 4.14 | 2.65 |
| Uncoated Groundwood | 4.42 | 2.60 | 2.58 |
| Thin Papers | | 1.41 | |
| Solid Bl. Bristols | 9.99 | 5.80 | .88 |
| Cotton Fiber | | .87 | |
| Tissue | 6.47 | 2.83 | .86 |
| **Board** | | | |
| Unbl. Kraft Liner. | 5.29 | 4.21 | 3.13 |
| Bl. Kraft Liner. | | 7.99 | |
| Bl. Kraft Folding | 10.32 | 11.21 | * |
| Semi-Chem. Corr. | 7.24 | 6.42 | 6.56 |
| Recycled Liner | | 3.10 | |
| Recycled Corr. | | 4.19 | |
| Recycled Folding | 2.88 | 1.94 | 1.76 |
| Constr. Paper & Bd. | 3.58 | 1.70 | 2.10 |
| Molded Pulp | | 2.63 | |
| Solid Bl. Board | 10.81 | 7.22 | 7.79 |
| All Other Board | 4.19 | 1.84 | 2.10 |
| **Pulp** | | | |
| Dissolving | | 14.74 | |
| Market | 14.88 | 10.74 | 9.53 |

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Source: Meta Systems estimates.

*Suppressed due to confidentiality.

## Alternative Option 4

Tables 7-12 and 7-13 show treatment cost estimates by subcategory and product sector for Alternative Option 4. The average annual cost increase is $5.20 per ton. The total capital costs are $1275.3 million and total annual costs are 398.1 million. The subcategories with the highest absolute cost increases are Market Bleached Kraft, Fine Bleached Kraft and Soda, Dissolving Sulfite Pulp, Papergrade Sulfite, Deink (Tissue), Tissue from Wastepaper, and Building Papers and Roofing Felt. The product sectors with the highest increases are Bleached Kraft Paper, Special Industrial Paper, Newsprint, Uncoated Freesheet, Cotton Fibre, Tissues, Bleached Kraft Linerboard, Bleached Kraft Foldingboard, Construction Paper and Board, Dissolving Pulp, and Market Pulp.

Tables 7-12a and 7-13a show the corresponding percentage increases in unit average costs over base production costs given in Tables 7-1 and 7-2. Subcategories with the highest percent cost increases are Market Bleached Kraft, BCT Bleached Kraft, Fine Bleached Kraft and Soda, Dissolving Sulfite Pulp, Miscellaneous Integrated Mills, Deink (Tissue) and Builders' Paper and Roofing Felt. Product sectors with the highest percent cost increases are Bleached Kraft Papers, Newsprint, Tissue, Bleached Kraft Foldingboard, Semi-Chemical Corrugating Medium, Construction Paper and Board, Solid Bleached Board, Dissolving Pulp and Market Pulp.

## Costs for New Sources -- Proposed Regulation

New sources are defined to be greenfield mills or major modifications of existing mills built 90 days after promulgation of the federal regulations for BCT and BAT controls. Costs were developed by the technical contractor for model mills in each subcategory. Only one technology option is considered for new sources in each subcategory. It is defined by the processes needed for new sources to attain the level of discharge of "exemplary" existing mills. These processes are described in Section 6.

Table 7-14 shows model mill daily capacity, total capital costs, capital costs per ton, and total annual costs per ton for treatment systems for model mills in each subcategory. These costs are significantly higher than comparable costs for existing sources, particularly in the secondary fiber and nonintegrated subcategories. This is partly because NSPS costs include costs of attaining BPT levels as well as the incremental cost of moving from BPT to BCT levels. Therefore these costs may overestimate the impact of the Proposed Regulation if the capacity expansion costs taken from the 308 Survey already include at least some treatment costs.

Table 7-12. Treatment Costs of Direct Dischargers By Subcategory: Alternative Option 4

| | Unit Total Annual Costs (1978 $/ton) (Averages for Low, Medium, and High Cost Mills) | | | Total Costs Millions of 1978 $ | |
|---|---|---|---|---|---|
| Integrated | Low | Medium | High | Capital | Total Annual |
| Dissolving Kraft | | * | | * | * |
| Market Bl. Kraft | | 9.2 | | 67.9 | 21.6 |
| BCT Bl. Kraft | | 8.2 | | 85.7 | 25.4 |
| Fine Bl. Kraft & Soda | 10.6 | 6.6 | 9.0 | 159.9 | 49.3 |
| Unbl. Kraft (Linerboard) | 2.8 | 2.3 | 4.6 | 67.4 | 20.5 |
| Unbl. Kraft (Bag) | | 5.8 | | 43.7 | 13.1 |
| Semi-Chemical | 2.1 | 3.7 | 5.3 | 34.4 | 11.5 |
| Unbl. Kraft and Semi-Chem. | | 4.0 | | 73.5 | 21.5 |
| Dissolving Sulfite Pulp | | 24.3 | | 81.2 | 27.5 |
| Papergrade Sulfite | | 15.0 | | 92.5 | 29.1 |
| Groundwood Thermo-Mechanical | | * | | * | * |
| Groundwood Coarse, Molded, Newsprint | | * | | * | * |
| Groundwood -- Fine Papers | | 5.9 | | 28.2 | 9.7 |
| Misc. Integrated Mills | 8.1 | 4.8 | 13.1 | 405.9 | 124.3 |
| Secondary Fiber | | | | | |
| Deink (Fine Papers) | | * | | * | * |
| Deink (Newsprint)† | | 0 | | 0 | 0 |
| Deink (Tissue) | | 14.6 | | 21.5 | 7.9 |
| Tissue from Wastepaper | | 13.5 | | 3.6 | 1.4 |
| Paperboard from Wastepaper | 2.1 | 4.6 | 2.0 | 7.3 | 8.3 |
| Wastepaper Molded Products | | * | | * | * |
| Builders Paper & Roofing Felt | | 14.3 | | 9.8 | 4.1 |
| Misc. Secondary Fiber Mills | | 3.8 | | 8.0 | 2.8 |
| Nonintegrated | | | | | |
| Nonintegrated Fine Papers | 6.6 | 1.2 | 8.6 | 12.9 | 4.0 |
| Nonintegrated Tissue Papers | 0.9 | 0.9 | * | 1.7 | 0.4 |
| Nonintegrated Lightweight | | 4.3 | | 4.7 | 1.1 |
| Nonintegrated Filter & Nonwoven | | 0 | | 0 | 0 |
| Nonintegrated Lightweight -- Electrical Allowance | | 0 | | 0 | 0 |
| Nonintegrated Paperboard | | 0 | | 0 | 0 |
| Misc. Nonintegrated Mills | 4.3 | 4.8 | 6.8 | 10.1 | 2.3 |
| Total | | | | 1275.3 | 398.1 |

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Source: Meta Systems estimates

†No direct dischargers in this subcategory.

*Suppressed due to confidentiality.

## TABLE 7-12A. PERCENT INCREASE IN PRODUCTION COSTS DUE TO TREATMENT REQUIREMENTS BY SUBCATEGORY:

### Alternative Option 4

| Integrated | Low | Medium | High |
|---|---|---|---|
| Dissolving Kraft | | * | |
| Market Bleached Kraft | | 4.63 | |
| BCT Bleached Kraft | | 3.15 | |
| Fine Bleached Kraft & Soda | 3.47 | 1.64 | 1.56 |
| Unbleached Kraft (Linerboard) | 1.99 | 1.46 | 1.67 |
| Unbleached Kraft (Bag) | | 3.00 | |
| Semi-Chemical | 1.69 | 2.62 | 2.50 |
| Unbleached Kraft and Semi-Chem. | | 2.74 | |
| Dissolving Sulfite Pulp | | 8.30 | |
| Papergrade Sulfite | | 2.98 | |
| Groundwood -- Thermo-Mechanical | | * | |
| Groundwood -- Coarse, Molded, Newsp. | | * | |
| Groundwood -- Fine Papers | | 1.78 | |
| Misc. Integrated Mills | 4.97 | 1.99 | 2.08 |
| **Secondary Fiber** | | | |
| Deink (Fine Papers) | | * | |
| Deink (Newsprint) | | 0 | |
| Deink (Tissue) | | 3.53 | |
| Tissue from Wastepaper | | 2.84 | |
| Paperboard from Wastepaper | 1.69 | 2.63 | .64 |
| Wastepaper Molded Products | | * | |
| Builders Paper & Roofing Felt | | 12.81 | |
| Misc. Secondary Fiber Mills | | .88 | |
| **Nonintegrated** | | | |
| Nonintegrated Fine Papers | 1.59 | .22 | 1.26 |
| Nonintegrated Tissue Papers | .28 | .12 | * |
| Nonintegrated Lightweight | | .47 | |
| Nonintegrated Filter & Non-woven | | 0 | |
| Nonintegrated Lightweight -- Electrical Allowance | | * | |
| Nonintegrated Paperboard | | 0 | |
| Misc. Nonintegrated Mills | .84 | .72 | .61 |

Source: Meta Systems estimates

*Suppressed due to confidentiality.

### Table 7-13. Treatment Costs of Direct Dischargers By Product Sector: Alternative Option 4

|  | Unit Total Annual Costs (1978 $/ton) (Averages for Low, Medium and High Cost Mills) |  |  | Total Costs Millions of 1978 $ |  |
|---|---|---|---|---|---|
| Paper | Low | Medium | High | Capital | Total Annual |
| Unbleached Kraft | 4.1 | 4.5 | 6.5 | 59.7 | 17.9 |
| Bleached Kraft | 8.9 | 8.9 | 4.2 | 25.0 | 7.6 |
| Glassine |  | 7.2 |  | 6.7 | 2.0 |
| Spec. Industrial | 8.3 | 5.6 | 2.4 | 10.0 | 2.9 |
| Newsprint | 8.4 | 5.2 | 6.6 | 84.4 | 26.1 |
| Coated Printing | 6.3 | 5.8 | 4.8 | 92.0 | 28.4 |
| Uncoated Freesheet | 8.7 | 6.5 | 7.7 | 173.9 | 54.3 |
| Uncoated Groundwood | 4.8 | 6.6 | 7.0 | 27.8 | 8.4 |
| Thin Papers | 5.3 | 2.6 | 8.5 | 12.1 | 4.3 |
| Solid Bl. Bristols | 7.8 | 7.1 | 6.4 | 17.8 | 5.2 |
| Cotton Fibre |  | 12.7 |  | 3.8 | 1.1 |
| Tissue | 9.8 | 12.7 | 4.2 | 84.5 | 27.0 |
| Board |  |  |  |  |  |
| Unbl. Kraft Liner. | 3.3 | 3.7 | 4.6 | 163.9 | 49.3 |
| Bl. Kraft Liner. |  | 7.0 |  | 3.5 | 1.0 |
| Bl. Kraft Folding | 6.9 | 7.6 | * | 52.3 | 15.6 |
| Semi-Chem. Corr. | 3.6 | 3.8 | 6.2 | 57.1 | 18.2 |
| Recycled Liner |  | 3.8 |  | 2.0 | 0.8 |
| Recycled Corr. |  | 2.7 |  | 3.2 | 1.4 |
| Recycled Folding | 3.8 | 3.7 | 2.6 | 8.1 | 3.2 |
| Constr. Paper & Bd. | 10.4 | 0.6 | 5.5 | 15.2 | 6.0 |
| Molded Pulp |  | 2.2 |  | 1.0 | 0.3 |
| Solid Bl. Board | 7.3 | 4.4 | 6.3 | 36.2 | 10.8 |
| All Other Board | 0.4 | 3.2 | 5.1 | 7.0 | 4.3 |
| Pulp |  |  |  |  |  |
| Dissolving |  | 18.0 |  | 81.6 | 27.2 |
| Market | 7.9 | 11.6 | 14.0 | 237.0 | 74.2 |
| Total |  |  |  | 1,275.3 | 398.1 |

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Source: Meta Systems estimates.

*Suppressed due to confidentiality.

## TABLE 7-13A. PERCENT INCREASE IN PRODUCTION COSTS DUE TO TREATMENT REQUIREMENTS BY PRODUCT SECTOR:

### Alternative Option 4

| | Averages for Low, Medium and High Cost Mills | | |
|---|---|---|---|
| **Paper** | Low | Medium | High |
| Unbleached Kraft | 2.50 | 2.84 | 2.17 |
| Bleached Kraft | 3.47 | 2.15 | 1.15 |
| Glassine | | 1.45 | |
| Spec. Industrial | 3.46 | .82 | .39 |
| Newsprint | 4.79 | 4.53 | 2.64 |
| Coated Printing | 3.76 | 3.52 | 2.82 |
| Uncoated Freesheet | 2.64 | 4.14 | 2.65 |
| Uncoated Groundwood | 4.73 | 2.60 | 2.58 |
| Thin Papers | | 1.41 | |
| Solid Bl. Bristols | 2.96 | 5.80 | .88 |
| Cotton Fiber | | .87 | |
| Tissue | 3.20 | 2.83 | .86 |
| **Board** | | | |
| Unbl. Kraft Liner. | 5.29 | 4.21 | 3.13 |
| Bl. Kraft Liner. | | 7.99 | |
| Bl. Kraft Folding | 3.27 | 11.21 | * |
| Semi-Chem. Corr. | 3.18 | 6.42 | 6.56 |
| Recycled Liner | | 3.10 | |
| Recycled Corr. | | 4.19 | |
| Recycled Folding | 2.88 | 1.94 | 1.76 |
| Constr. Paper & Bd. | 8.86 | 1.70 | 2.10 |
| Molded Pulp | | 2.63 | |
| Solid Bl. Board | 3.74 | 7.72 | 7.79 |
| All Other Board | 4.19 | 1.84 | 2.10 |
| **Pulp** | | | |
| Dissolving | | 6.07 | |
| Market | 6.95 | 10.74 | 9.53 |

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Source: Meta Systems estimates.

*Suppressed due to confidentiality.

As a comparison, Table 7-14 also shows average unit capital costs of treatment systems in place in existing mills taken from the 308 Survey. In most cases these reflect BPT treatment levels for large relatively recent mills. The following subcategories have BPT costs as a large fraction of NSPS costs (over 50 percent): Fine Bleached Kraft, Papergrade Sulfite, and Deink (Tissue).

As noted in the section on costs for existing sources, it is very difficult to project total costs of compliance for new sources. First, the fraction of predicted capacity expansion in a given year which will be classified as a new source must be determined. Secondly, that amount of capacity must be allocated among various subcategories. Through 1983, the fraction of new source capacity in each product sector is projected based on API forecasts of new machines and the capacity expansion plans of existing mills reported in the 308 Survey. Thereafter, new sources should occupy an increasing fraction of capacity expansion. The mix of subcategories is assumed to be the same one as that used for expansions of existing capacity. (See previous subsection.) Estimates of total costs of compliance for 1982-83 are given in Table 7-15. (1982 is assumed to be the first year for which new source standards apply.)

## Indirect Impacts - Demand/Supply Analysis

Tables 7-16 through 7-20 show the results of the demand/supply analyses for the Proposed Regulation and the four Alternative Options. Each table shows the percent changes in price, output and contribution to capital as well as the average dollar per ton price increase resulting from the inclusion of treatment costs in mills' costs of production. Industry-wide price and output changes are also given for each option.

Because increases in cost affect the equilibrium values of both price and output, the relative impacts of a treatment option across different product sectors cannot be measured simply by the relative impacts on price. The distribution of the impact between price and output depends on the elasticities of supply and demand. This can be seen in Figure 7-1, where DD is the demand curve and SS and S'S' the before and after-control supply curves. The relative price impact is (P'-P)/P and the quantity impact (Q'-Q)/Q. The flatter (more elastic) both the supply and demand curves are, the greater will be the effect on quantity compared to the effect on price.

The effect on the contribution to capital is an important indicator of the magnitude and distribution of treatment costs among low- and high-cost producers, but must be interpreted with some care. In Figure 7-1, pre-control contribution to capital is measured by the

## Table 7-14. Costs of Compliance for New Sources, Model Mills: Proposed Regulation

| Integrated | Mill Capacity (ton/d) | Total Capital Costs (1978 $x $10^6$) | Capital Costs ($/ton) | Total Annual Costs† ($/ton) | BPT Capital Costs for Existing Mills ($/ton) |
|---|---|---|---|---|---|
| Dissolving Kraft | 1000 | 33.1 | 100.3 | 38.0 | 29.0 |
| Market Bleached Kraft | 750 | 20.7 | 83.5 | 28.4 | 20.3 |
| BCT Bleached Kraft | 500 | 17.1 | 103.4 | 35.4 | 24.8 |
| Fine Bleached Kraft & Soda | 750 | 19.0 | 76.9 | 27.4 | 41.5 |
| Unbleached Kraft (Linerboard) | 500 | 8.2 | 49.6 | 16.2 | 5.3 |
| Unbleached Kraft (Bag) | 1000 | 13.6 | 41.2 | 13.4 | 12.7 |
| Semi-Chemical | 500 | 8.9 | 54.2 | 18.0 | 12.2 |
| Unbleached Kraft and Semi-Chem. | 1500 | 21.2 | 42.9 | 14.5 | 11.4 |
| Dissolving Sulfite Pulp | 500 | 40.4 | 244.9 | 82.9 | 26.5 |
| Papergrade Sulfite | 750 | 39.8 | 160.8 | 54.1 | 84.4 |
| Groundwood -- Thermo-Mechanical | 500 | 9.1 | 55.4 | 19.7 | * |
| Groundwood -- Coarse, Molded, News | 500 | 10.2 | 61.7 | 21.8 | * |
| Groundwood -- Fine Papers | 500 | 10.9 | 66.3 | 22.1 | 25.7 |
| Misc. Integrated Mills | - | - | - | - | 21.7 |
| **Secondary Fiber** | | | | | |
| Deink (Fine Papers) | 500 | 11.2 | 67.8 | 30.0 | * |
| Deink (Newsprint) | 500 | 12.0 | 72.9 | 30.4 | - |
| Deink (Tissue) | 500 | 13.2 | 80.3 | 33.7 | 66.7 |
| Tissue from Wastepaper | 10 | 1.3 | 389.7 | 152.4 | 31.8 |
| Paperboard from Wastepaper | 500 | 4.4 | 26.5 | 9.6 | 6.7 |
| Wastepaper Molded Products | 50 | 1.5 | 89.5 | 33.2 | * |
| Builders Paper & Roofing Felt | 150 | 2.5 | 49.9 | 19.8 | * |
| Misc. Secondary Fiber Mills | - | - | - | - | 15.5 |
| **Nonintegrated** | | | | | |
| Nonintegrated Fine Papers | 250 | 4.4 | 53.9 | 18.6 | 22.5 |
| Nonintegrated Tissue Papers | 250 | 4.1 | 49.4 | 21.7 | 8.4 |
| Nonintegrated Lightweight | 50 | 2.7 | 164.3 | 67.5 | 34.0 |
| Nonintegrated Filter & Nonwoven | 25 | 1.7 | 205.8 | 85.0 | 54.1 |
| Nonintegrated Lightweight -- Electrical Allowance | 50 | 2.9 | 178.7 | 73.5 | * |
| Nonintegrated Paperboard | 50 | 1.6 | 97.9 | 43.4 | 18.4 |
| Misc. Nonintegrated Mills | - | - | - | - | 18.7 |

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Source: E.C. Jordan, 308 Survey.

†Includes O & M energy and capital recovery (22%).

*Suppressed due to confidentiality.

## Table 7-15. Total Costs of Compliance, 1982-83, for New Sources: Proposed Regulation (Millions of 1978 $)

| Paper | Capital Costs | Total Annual Costs |
|---|---|---|
| Unbleached Kraft | 9.7 | 3.2 |
| Bleached Kraft | 0 | 0 |
| Glassine | 0 | 0 |
| Spec. Industrial | 0.2 | 0.1 |
| Newsprint | 34.3 | 13.9 |
| Coated Printing | 21.9 | 7.6 |
| Uncoated Freesheet | 15.1 | 5.3 |
| Uncoated Groundwood | 8.2 | 3.2 |
| Thin Papers | 0 | 0 |
| Solid Bl. Bristols | 0 | 0 |
| Cotton Fibre | 0 | 0 |
| Tissue | 19.3 | 7.2 |
| **Board** | | |
| Unbl. Kraft Liner. | 38.8 | 12.8 |
| Bl. Kraft Liner. | 0 | 0 |
| Bl. Kraft Folding | 1.3 | 0.4 |
| Semi-Chem. Corr. | 21.5 | 7.1 |
| Recycled Liner | 0 | 0 |
| Recycled Corr. | .02 | .01 |
| Recycled Folding | 0 | 0 |
| Constr. Paper & Bd. | 1.9 | 0.8 |
| Molded Pulp | 0 | 0 |
| Solid Bl. Board | 1.6 | 0.5 |
| All Other Board | 0.8 | 0.3 |
| **Pulp** | | |
| Dissolving | 0 | 0 |
| Market | 0 | 0 |
| **Total** | 174.8 | 62.5 |

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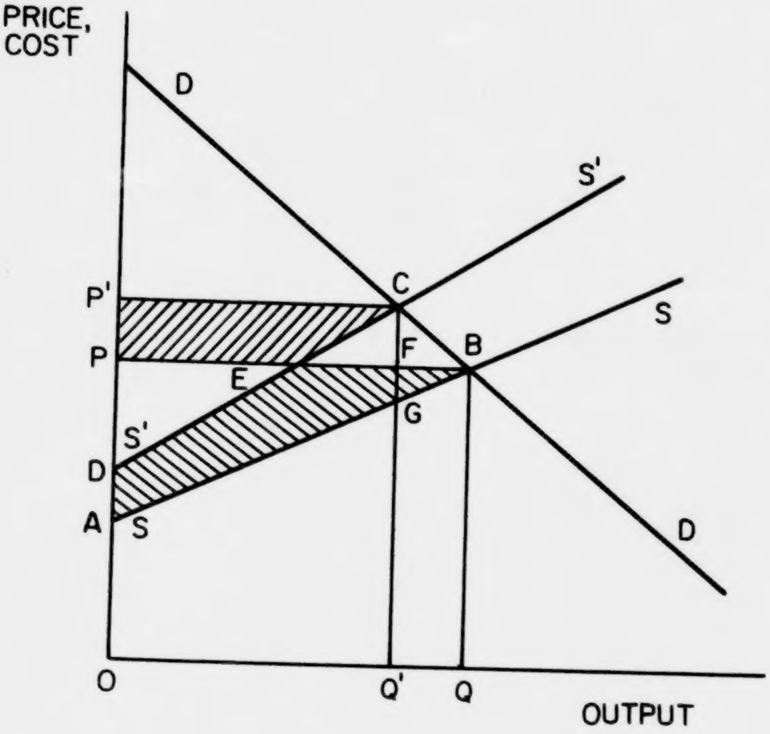
Source: Meta Systems estimates

FIGURE 7-1: The Effect of Elasticity on the Relative Changes in Price, Quantity, and Contribution to Capital


PRICE, COST
D
S'
C
P'
S
P
F
B
E
G
S'
D
A
S
D
O
Q'
Q
OUTPUT

area ABP and post-control contribution to capital by the area DCP'. The net change is given by the area PECP' ( ▧ ) less the area ABED ( ▨ ) and the relative change is (PECP'-ABED)/ABP. It can be seen that the amount PECP is very close to (P'-P)Q' and hence depends mainly on the change in costs at the margin which affect price and output. On the other hand, area ABED roughly measures the total amount of treatment costs, and hence will be affected by whether treatment costs of inframarginal producers are low or high relative to the marginal producer. Lastly, for a given base quantity OQ, original contribution ABP depends on the shape of the supply curve.

Because of these points, for a given percent increase, the relative change in contribution could be large either if cost increases for inframarginal producers are high relative to marginal producers or if the base level of contribution is low (SS relatively flat) or both. Therefore it is useful to compare the percent change in contribution to the ratio of contribution to total revenues (ABP/OQBP in Figure 7-1) to determine the extent to which, for example, a small base level of contribution might be the cause of a large percent change in contribution due to treatment costs.

### Proposed Regulation

Table 7-16 shows the impacts on price, output and contribution to capital projected to result from treatment costs due to the Proposed Regulation. The relative price increases range from 0 percent to 3.57 percent, and the absolute price changes range from $0 to $23.30 per ton. The overall average price increase is $4.10 per ton. Changes in output range from -5.94 percent to plus 1.90 percent. The overall loss in output is 480,000 tons per year. In general, relative price changes are greater than relative output changes, reflecting the inelastic demand for most paper and board products. Exceptions to this are Bleached Kraft Papers, Glassine and Greaseproof Papers, and Recycled Linerboard. Impacts in the board sectors show a greater range than in the paper sectors mainly due to the large cost increases in bleached board product sectors.

Paper grades with relatively high price impacts are Newsprint (3.20 percent), and Glassine and Greaseproof (1.83 percent). Glassine and Greaseproof has the highest overall impact with a 5.94 percent loss in output as well. Uncoated Groundwood, Thin Papers, Cotton Fibre, and Tissue show very small impacts.

Bleached Kraft Linerboard, Bleached Kraft Foldingboard, and Semi-Chemical Corrugating Medium show the greatest price increases of the board grades. Bleached Kraft Foldingboard has the highest overall impacts, with a 2.52 percent drop in output as well. The lowest impacts are in the recycled grades.

## Table 7-16. Summary of Demand/Supply Analysis Proposed Regulation

| | Average Percent Changes from Base Case, 1983-85 | | | |
|---|---|---|---|---|
| Paper | Price | Output | Contribution to Capital | Average Price Increase, 1983-85 (1978 $/ton) |
| Unbleached Kraft | .69 | - .75 | -1.30 | 2.00 |
| Bleached Kraft | .83 | -2.26 | -5.86 | 2.90 |
| Glassine | 1.83 | -5.94 | 7.68 | 16.00 |
| Spec. Industrial | .61 | - .48 | .92 | 5.80 |
| Newsprint | 3.20 | - .87 | 3.75 | 9.60 |
| Coated Printing | .49 | - .20 | -1.01 | 2.90 |
| Uncoated Freesheet | .80 | - .19 | - .51 | 4.60 |
| Uncoated Groundwood | 0 | 0 | -2.58 | 0 |
| Thin Papers | .20 | - .08 | -1.66 | 1.30 |
| Solid Bl. Bristols | .67 | - .24 | - .77 | 3.30 |
| Cotton Fibre | .08 | - .15 | - .16 | 1.20 |
| Tissue | .23 | - .01 | - .31 | 2.20 |
| **Board** | | | | |
| Unbl. Kraft Liner. | 1.86 | - .94 | .85 | 4.30 |
| Bl. Kraft Liner. | 2.63 | - .99 | 1.47 | 7.00 |
| Bl. Kraft Folding | 3.57 | -2.52 | -3.72 | 15.60 |
| Semi-Chem. Corr. | 2.48 | -1.76 | 1.63 | 5.50 |
| Recycled Liner | .18 | .01 | .57 | 0.40 |
| Recycled Corr. | 1.41 | 1.90 | 1.94 | 3.00 |
| Recycled Folding | .07 | - .08 | - .51 | .30 |
| Constr. Paper & Bd. | 0 | 0 | - .27 | 0 |
| Molded Pulp† | | | | |
| Solid Bl. Board | .72 | - .64 | - .36 | 3.30 |
| All Other Board | .18 | - .11 | -1.43 | 0.50 |
| **Pulp** | | | | |
| Dissolving | 2.85 | -2.09 | 4.04 | 10.40 |
| Market† | | | | |
| Overall Average | 1.02 | - .63 | - .42 | 4.10 |

Source: Meta Systems estimates.

†No demand/supply model.

Recycled Linerboard and Recycled Corrugating Medium actually show increases in both price and output. This results from their roles as substitutes for their corresponding solid grades, Bleached and Unbleached Linerboard and Semi-Chemical Corrugating Medium, respectively. Table 7-5 shows that unit treatment costs are slightly less for the recycled grades than the corresponding solid grades. Since the output of the solid grades is much larger than the recycled grades, the cross-price effect outweighs the own-price effect, and demand for recycled board grades actually increases. See Appendix 2-B for a discussion of the modeling of demand for the linerboard and corrugating medium product sectors.

Dissolving Pulp shows small price and output impacts because only mills in the Dissolving Kraft subcategory (three out of nine total) are subject to BCT regulations.

Percent changes in contribution show a pronounced disparity. Although most sectors show net losses, a few such as Glassine and Greaseproof, Newsprint, and Semi-Chemical and Recycled Corrugating Medium show gains. This implies that at least some firms will benefit from pollution controls. This result can occur when individual firms experience cost increases less than the price increases of the goods they produce. For example, indirect dischargers face no treatment costs under the Proposed Regulation. This result is confirmed in the closure analysis, where some base case closures reopen under the option. The largest declines in contribution are shown by Bleached Kraft Papers (-5.86 percent) and Bleached Kraft Foldingboard (-3.72 percent).

### Alternative Option 1

Results for Alternative Option 1 are shown in Table 7-17. Impacts in Alternative Option 1 are the smallest of all the three options not based on exemplary mill costs. All price and quantity impacts except for Dissolving Pulp are less than one percent. The overall price increase is $1.20 per ton and the overall output change is 99,000 tons per year. Impacts on contribution show a somewhat greater range, from an increase of 1.28 percent for Special Industrial Papers to decreases of 1.67 percent for Bleached Kraft Papers, 3.41 percent for Semi-Chemical Corrugating Medium, and 4.13 percent for Dissolving Pulp.

In the paper grades, price impacts range from 0 to 0.6 percent, output impacts from 0 to -0.73 percent, and contribution impacts from 1.28 percent for Special Industrial Paper to -1.21 percent for Newsprint and -1.67 percent for Bleached Kraft Paper.

In the board grades, price impacts range from -0.22 percent for Recycled Corrugating to 0.26 percent for Unbleached Kraft Linerboard, output impacts range from plus 0.02 percent for Recycled Foldingboard to -0.51 percent for Bleached Kraft Foldingboard.

## Table 7-17. Summary of Demand/Supply Analysis: Alternative Option 1

| | Average Percent Changes from Base Case, 1983-85 | | | |
|---|---|---|---|---|
| **Paper** | Price | Output | Contribution to Capital | Average Price Increase, 1983-85 (1978 $/ton) |
| Unbleached Kraft | .16 | -.18 | - .58 | .50 |
| Bleached Kraft | .24 | -.67 | -1.67 | .80 |
| Glassine | .29 | -.73 | - .72 | 2.60 |
| Spec. Industrial | .61 | -.48 | 1.28 | 5.80 |
| Newsprint | .61 | -.17 | -1.21 | 1.80 |
| Coated Printing | .24 | -.10 | - .57 | 1.40 |
| Uncoated Freesheet | .41 | -.10 | - .68 | 2.40 |
| Uncoated Groundwood | 0 | 0 | - .66 | - .60 |
| Thin Papers | .30 | -.12 | .87 | 2.20 |
| Solid Bl. Bristols | .29 | -.10 | - .25 | 1.40 |
| Cotton Fibre | 0 | 0 | - .44 | 0 |
| Tissue | 0 | 0 | - .60 | - .40 |
| **Board** | | | | |
| Unbl. Kraft Liner. | .86 | -.16 | .64 | 2.00 |
| Bl. Kraft Liner. | .84 | -.15 | -1.38 | 2.20 |
| Bl. Kraft Folding. | .75 | -.53 | - .44 | 3.30 |
| Semi-Chem. Corr. | -.17 | -.17 | -3.41 | - .40 |
| Recycled Liner. | .02 | -.07 | - .38 | 0 |
| Recycled Corr. | -.22 | -.18 | -1.98 | .50 |
| Recycled Folding. | .01 | .02 | .49 | 0 |
| Constr. Paper & Bd. | .03 | .00 | - .07 | .10 |
| Molded Pulp | - | - | - | - |
| Solid Bl. Board | .26 | -.23 | - .96 | 1.20 |
| All Other Board | .14 | -.04 | - .67 | .40 |
| **Pulp** | | | | |
| Dissolving | 3.74 | -1.32 | -4.13 | 13.30 |
| Market | - | - | - | - |
| **Overall Average** | .30 | -.12 | - .51 | 1.20 |

---

Source: Meta Systems estimates

Both Semi-Chemical Corrugating Medium and Recycled Corrugating Medium show decreases in both price and output. This results from the complementary relationship between linerboard and corrugating medium. Since both are used to make fibre boxes, the demand for each depends on the sum of the costs of linerboard and corrugating medium, weighted by their respective shares in the composition of fibre boxes. A rise in the cost of one component reduces demand for the other. If the fall in demand is large enough, it will outweight the upward shift in the supply curve, causing both price and output to fall.

Dissolving Pulp has the largest overall impacts, including a 3.74 percent price increase and a 4.13 percent loss in contribution to capital.

### Alternative Option 2

Table 7-18 shows the results for Alternative Option 2. Compared to Alternative Option 1, price and output impacts are substantially greater in most product sectors. The overall average price increase is $3.90 per ton or .98 percent and the decrease in output is 401,000 tons/year or -.51 percent. Movements in contribution to capital show no overall pattern, some increasing and some decreasing. Increases in contribution to capital relative to Alternative Option 1 would occur in product sectors where the bulk of cost increases takes place in high cost mills. This raises price without similarly raising the costs of inframarginal mills, thereby increasing contribution to capital overall. Sectors in which this occurs are Glassine and Greaseproof, Newsprint, Unbleached Linerboard, Bleached Linerboard, and Semi-Chemical Corrugating Medium. On the other hand, in sectors where the bulk of cost increases occur in low cost mills, contribution to capital decreases although price does not change much. This occurs in Special Industrial Papers and Thin Papers. Product sectors with no significant changes from Option 1 are Cotton Fibre and All Other Board.

In the paper grades, price impacts range from 0 for Cotton Fibre to 1.93 percent for Glassine and Greaseproof, 2.39 percent for Newsprint and 1.20 percent for Uncoated Freesheet. Changes in output bear about the same relation to price changes as in Option 1. Changes in contribution to capital range from an increase of 1.19 percent for Coated Printing and 1.11 percent for Glassine and Greaseproof to decreases of 1.93 percent for Solid Bleached Bristols and 2.63 percent for Unbleached Kraft Papers. Overall, Glassine and Greaseproof is the hardest hit sector.

In the board grades, price changes range from -0.52 percent for Recycled Linerboard to 3.46 percent for Bleached Linerboard and 1.76 percent for Bleached Foldingboard. The biggest decreases occur in Semi-Chemical Corrugating (-2.51 percent) and Recycled Linerboard (-2.56 percent). Bleached Foldingboard again has the largest overall impact.

## Table 7-18. Summary of Demand/Supply Analysis: Alternative Option 2

| | Average Percent Changes from Base Case, 1983-85 | | | |
|---|---|---|---|---|
| Paper | Price | Output | Contribution to Capital | Average Price Increase, 1983-85 (1978 $/ton) |
| Unbleached Kraft | .72 | - .81 | -2.63 | 2.10 |
| Bleached Kraft | .34 | - .92 | -1.70 | 1.20 |
| Glassine | 1.93 | -6.46 | 1.11 | 16.90 |
| Spec. Industrial | .54 | - .42 | .60 | 5.10 |
| Newsprint | 2.39 | - .66 | .98 | 7.20 |
| Coated Printing | .82 | - .33 | 1.19 | 4.90 |
| Uncoated Freesheet | 1.20 | - .29 | -1.26 | 7.00 |
| Uncoated Groundwood | .29 | - .61 | - .81 | 1.40 |
| Thin Papers | .30 | - .12 | - .87 | 2.20 |
| Solid Bl. Bristols | .84 | - .30 | -1.93 | 4.10 |
| Cotton Fibre | 0 | 0 | - .44 | 0 |
| Tissue | .44 | - .02 | - .57 | 4.20 |
| Board | | | | |
| Unbl. Kraft Liner. | .86 | - .65 | 4.30 | 2.00 |
| Bl. Kraft Liner. | 3.46 | - .93 | 4.24 | 9.20 |
| Bl. Kraft Folding. | 1.76 | -1.24 | -2.43 | 7.80 |
| Semi-Chem. Corr. | 2.21 | - .87 | -2.51 | 4.90 |
| Recycled Liner. | - .52 | -1.44 | -2.56 | -1.10 |
| Recycled Corr. | 1.86 | - .22 | 2.14 | 3.90 |
| Recycled Folding. | .09 | - .11 | .70 | .30 |
| Constr. Paper & Bd. | .03 | 0 | - .48 | .10 |
| Molded Pulp | - | - | - | - |
| Solid Bl. Board | 1.24 | -1.08 | - .18 | 5.80 |
| All Other Board | .20 | - .12 | - .86 | .50 |
| Pulp | | | | |
| Dissolving | 5.28 | -1.83 | -9.57 | 18.80 |
| Market | - | - | - | - |
| Overall Average | .98 | - .51 | -1.27 | 3.90 |

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Source: Meta Systems estimates

Dissolving Pulp has a larger impact than in Alternative Option 1, and at 5.28 percent it still has the highest price impact overall.

### Alternative Option 3

Table 7-19 shows the results for Alternative Option 3. Relative price increases range from -.80 percent to 9.61 percent and absolute price increases range from $-1.60 to $31.80 per ton. The overall average price increase is $5.90 per ton or 1.47 percent. Changes in output range from -6.57 percent to 0.66 percent. The overall average decrease in output is 630,000 tons/year or -1.80 percent. Paper grades with relatively high price impacts are Glassine and Greaseproof (1.97 percent), Newsprint (2.60 percent), and Thin Papers (1.72 percent). These are not large in any absolute sense, however. Special Industrial Papers, Uncoated Groundwood, Cotton Fibre, and Tissues show very small impacts. Overall, the most affected grade is Glassine and Greaseproof, with a relatively significant price increase and a large drop in output.

The bleached grades of linerboard, foldingboard, and solid board together with Semi-Chemical Corrugating Medium show the largest price increases of the board grades. Bleached Kraft Foldingboard has the greatest overall impact, since it also shows a large decrease in output (3.63 percent). The lowest impacts are in the recycled grades, although Recycled Corrugating Medium shows a large price increase and increase in output due to substitution away from Semi-Chemical Corrugating Medium.

Relative changes in contribution to capital range from -12.59 percent for Dissolving Pulp and -6.75 percent for Recycled Linerboard to an increase of 38.4 percent for Bleached Linerboard. The significant reduction in Recycled Linerboard occurs because both price and output decline. (See the discussion of this in the section on Alternative Option 1.) The large increase for Bleached Linerboard results from the large price increase, low demand elasticity, and low base level of contribution to capital (only 18 percent of total revenues, see Table 7-3).

### Alternative Option 4

The results for Alternative Option 4 are given in Table 7-20. Results for all sectors except Construction Paper and Board and Dissolving Pulp are identical to those of the Proposed Regulation. Differences between this option and the Proposed Regulation occur only in the Dissolving Sulfite Pulp and Builders' Paper and Roofing Felt subcategories. These subcategories are exempt under the Proposed Regulation

## Table 7-19. Summary of Demand/Supply Analysis: Alternative Option 3

| | Average Percent Changes from Base Case, 1983-85 | | | |
|---|---|---|---|---|
| **Paper** | Price | Output | Contribution to Capital | Average Price Increase, 1983-85 (1978 $/ton) |
| Unbleached Kraft | .79 | - .88 | -2.27 | 2.30 |
| Bleached Kraft | .44 | -1.22 | -2.30 | 1.50 |
| Glassine | 1.97 | -6.57 | .72 | 17.20 |
| Spec. Industrial | .56 | - .44 | .59 | 5.30 |
| Newsprint | 2.60 | - .72 | - .34 | 7.80 |
| Coated Printing | 1.18 | - .48 | -1.24 | 7.10 |
| Uncoated Freesheet | 1.52 | - .37 | -1.89 | 8.80 |
| Uncoated Groundwood | .29 | - .62 | -2.86 | 1.40 |
| Thin Papers | 1.72 | - .70 | 3.52 | 12.70 |
| Solid Bl. Bristols | 1.49 | - .53 | -3.23 | 7.30 |
| Cotton Fibre | 0 | 0 | - .58 | 0 |
| Tissue | .44 | - .02 | -1.62 | 4.20 |
| **Board** | | | | |
| Unbl. Kraft Liner. | 1.40 | -1.03 | -3.64 | 3.20 |
| Bl. Kraft Liner. | 7.28 | -1.63 | 38.4 | 19.40 |
| Bl. Kraft Folding. | 5.14 | -3.63 | -2.43 | 22.80 |
| Semi-Chem. Corr. | 3.52 | -1.64 | - .88 | 7.70 |
| Recycled Liner. | -.80 | -2.27 | -6.75 | - 1.60 |
| Recycled Corr. | 2.68 | .66 | 2.91 | 5.70 |
| Recycled Folding. | .12 | .15 | - .14 | .40 |
| Constr. Paper & Bd. | .27 | - .08 | .05 | .70 |
| Molded Pulp | - | - | - | - |
| Solid Bl. Board | 2.66 | -2.30 | -2.23 | 12.30 |
| All Other Board | .36 | - .19 | -1.49 | 1.10 |
| **Pulp** | | | | |
| Dissolving | 8.96 | -3.11 | -12.59 | 31.80 |
| Market | - | - | - | - |
| **Overall Average** | 1.47 | -1.80 | -1.71 | 5.90 |

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Source: Meta Systems estimates

### Table 7-20. Summary of Demand/Supply Analysis Alternative Option 4

|  | Average Percent Changes from Base Case, 1983-85 |  |  |  |
|---|---|---|---|---|
| Paper | Price | Output | Contribution to Capital | Average Price Increase, 1983-85 (1978 $/ton) |
| Unbleached Kraft | .69 | - .75 | -1.30 | 2.00 |
| Bleached Kraft | .83 | -2.26 | -5.86 | 2.90 |
| Glassine | 1.83 | -5.94 | 7.68 | 16.00 |
| Spec. Industrial | .61 | - .48 | .92 | 5.80 |
| Newsprint | 3.20 | - .87 | 3.75 | 9.60 |
| Coated Printing | .49 | - .20 | -1.01 | 2.90 |
| Uncoated Freesheet | .80 | - .19 | - .51 | 4.60 |
| Uncoated Groundwood | 0 | 0 | -2.58 | 0 |
| Thin Papers | .20 | - .08 | -1.66 | 1.30 |
| Solid Bl. Bristols | .67 | - .24 | - .77 | 3.30 |
| Cotton Fibre | .08 | - .15 | - .16 | 1.20 |
| Tissue | .23 | - .01 | - .31 | 2.20 |
| Board |  |  |  |  |
| Unbl. Kraft Liner. | 1.86 | - .94 | .85 | 4.30 |
| Bl. Kraft Liner. | 2.63 | - .99 | 1.47 | 7.00 |
| Bl. Kraft Folding | 3.57 | -2.52 | -3.72 | 15.60 |
| Semi-Chem. Corr. | 2.48 | -1.76 | 1.63 | 5.50 |
| Recycled Liner | .18 | .01 | .57 | 0.40 |
| Recycled Corr. | 1.41 | 1.90 | 1.94 | 3.00 |
| Recycled Folding | .07 | - .08 | - .51 | .30 |
| Constr. Paper & Bd. | 0 | 0 | - .98 | 0 |
| Molded Pulp† |  |  |  |  |
| Solid Bl. Board | .72 | - .64 | - .36 | 3.30 |
| All Other Board | .18 | - .11 | -1.43 | 0.50 |
| Pulp |  |  |  |  |
| Dissolving | 5.35 | -3.99 | -4.59 | 19.50 |
| Market† |  |  |  |  |
| Overall Average | 1.06 | - .66 | - .54 | 4.30 |

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Source: Meta Systems estimates.

†No demand/supply analysis.

but are required to attain BCT levels under this option. The overall price increase is $4.30 per ton or 1.06 percent, and the decrease in output is 507,000 tons per year or -.66 percent.

When mills in the Builders' Paper and Roofing Felt subcategory are assigned treatment costs, price and output in the Construction Paper and Board product sector are unaffected, but contribution to capital is lower, .98 percent lower than in the base case. As can be seen from comparing Tables 7-5 and 7-13, only relatively low-cost mills in the product sector are affected by the change.

Not exempting the Dissolving Sulfite Pulp subcategory affects both the Dissolving Pulp and Market Pulp subcategories. However, no demand/supply analysis is available for the latter. The impacts on Dissolving Pulp are the largest of any product sector under the option. Price increases 5.35 percent or $19.50 per ton, output decreases 3.99 percent, and contribution to capital decreases 4.59 percent.

## Capital Availability Analysis

This section describes the results of the capital availability analysis. These results can be used to evaluate both the plausibility of the capital expansion forecasts in the study even in the absence of BCT and BAT pollution costs, and the ability of the industry to finance required investments in pollution control. Two measures of this ability are used: the net present value of a unit of new capacity; and the relationship of income after taxes, interest and depreciation in a given year to the amounts required for (a) bringing existing capacity into compliance with the Proposed Regulation, and (b) normal capacity expansion, including required pollution control costs.

The first measure assumes that capital markets will provide the necessary capital if investments in new capacity are profitable, and hence focuses on the net present value of a unit of new capacity in each sector. The second measure asks instead whether or not the required investments can be financed internally in the various sectors. Both measures have a certain amount of built-in sensitivity analysis, because one can test how much the cost and revenue components of each measure can vary while still meeting the profitability or availability criterion.

These measures were calculated for the Base Case, the Proposed Regulation, and the Alternative Options. Most product sectors analyzed meet both the profitability and internal financing criteria under all options. The exceptions are Bleached Kraft Papers, Bleached Kraft Linerboard, Unbleached Kraft Linerboard, Bleached Kraft Foldingboard, Semi-Chemical Corrugating, Newsprint, Coated Printing Paper, Uncoated Groundwood and Dissolving Pulp. All except Bleached Kraft

Linerboard and Bleached Kraft Foldingboard meet the profitability criterion. The factors contributing to these results are discussed below.

In addition, the ability of individual mills to meet capital costs out of current cash flow is analyzed. Under the Proposed Regulation, 56 mills have capital costs of pollution control greater than annual cash flow.

A present value was calculated for an investment in new capacity in each product sector in each year from 1979 to 1985 in order to establish a trend of profitability. For example, Table 7-21 shows 1982 values for unit capital costs, K, the net present value of the investment, PV, based on the forecast of prices from the demand/supply analysis for the Base Case, and the ratio of present value to capital costs, PV/K. The results for other years are similar. The ratio PV/K shows the profitability of the investment and the sensitivity of the result to different assumptions about costs. If the ratio is close to zero, the new capacity just breaks even under our assumptions, whereas if the ratio is 1.0 or greater, there is a very comfortable margin for error. In fact, one can use the results of Table 7-21 to calculate how high variable or capital costs could be before the capacity investment become unprofitable. PV and PV/K are also given for the Proposed Regulation and Alternative Options 1-4 in Tables 7-22 to 7-26.

Tables 7-21 to 7-26 also give the comparison of income net of taxes, interest and depreciation (referred to here as "cash flow") with total capital costs of bringing existing capacity (as of 1982) into compliance and the capital costs of capacity expansion (including treatment costs) for the year 1982. This is consistent with the assumption in the demand/supply analysis that mills start operating their treatment systems in 1983. This comparison implicitly makes the very conservative assumption that all capital costs for pollution control and capacity expansion must be provided from that year's cash flow. This is conservative because if capital costs exceed available cash flow for a given sector, firms will likely be able to either shift funds from other sectors which have surpluses or borrow the remainder. On the other hand, the comparison neglects other demands on capital such as compliance with other unrelated federal regulations.

Capital costs of pollution control and capacity expansion are determined in the same manner as was used for total costs of compliance in an earlier part of this Section. For capacity in place by 1978, capital costs were computed using production data from the 308 Survey. For additions to capacity after 1978, pollution control costs were estimated by forecasting the amount of capacity expansion in each sector, the mix of technical subcategories making up that expansion, and the mix of new sources and expansions of existing mills. The results here are grouped somewhat differently than in the subsection on costs of compliance. Capital costs of pollution control for additions to capacity in 1983 are combined with the base capital costs of that expansion and hence appear in the third column labeled "Expansion Cost, 1982." Base capital costs of expansion are the product of the capacity expansion forecast and the unit capital cost described in the present value analysis.

Base Case

Table 7-21 shows the results of the capital availability analysis for the Base Case. Investments in all product sectors except Bleached Kraft Papers and Bleached Kraft Linerboard are profitable, but several other sectors, Newsprint, Solid Bleached Bristols, Unbleached Kraft Linerboard, Bleached Foldingboard, Semi-Chemical Corrugating Medium, and Dissolving Pulp, have relatively low profitability. A comparison of Table 7-21 and Table 7-3 shows that the percent differences in capital costs per ton between bleached grades and the corresponding unbleached grades is much greater than the percentage price differences. For example, Bleached Kraft Paper prices are only $57/ton higher than for Unbleached Paper, but capital costs are almost double ($1202/ton vs. $614/ton). The poor performance of Newsprint stems from its having capital costs higher than those for Uncoated Groundwood although its price is lower. The marginal profitability of Unbleached Kraft Linerboard and Semi-Chemical Corrugating Medium may just reflect their competitiveness and relative homogeneity. Dissolving Pulp has static demand.

The most striking result is that investment in most of the product sectors is so profitable. The highest PV ratios are found in Cotton Fibre, Tissue, Recycled Foldingboard, Construction Paper and Board, and All Other Board. The high net present values for Glassine and Greaseproof and Cotton Fibre are unexpected because no capacity growth is forecast for these sectors. This suggests that the capital costs derived from the 308 Survey are low. On the other hand, the results show that investments in most sectors would be profitable even if capital costs were substantially higher.

Of the sectors pinpointed as weak by this analysis, there is corroborating evidence for the three bleached paper and board grades. Capacity utilization in Bleached Kraft Papers if projected to remain very low, about 55 percent. In fact, DRI forecasts that production of Bleached Kraft Papers will actually decline slightly over the period

# Table 7-21. Capital Availability Analysis: Base Case

| | Present Value of ---Unit of New Capacity--- | | | Internal Funds ---Millions of 1978 $--- | |
|---|---|---|---|---|---|
| Paper | Capital Cost ($/ton) | Net PV ($/ton) | Net PV / Cap. Cost | Total Net Income 1982 | Expansion Cost 1982 |
| Unbleached Kraft | 614 | 587 | 0.96 | 195.4 | 102.5 |
| Bleached Kraft | 1,202 | - 627 | -0.52 | - 27.7 | 13.0 |
| Glassine | 831 | 2,348 | 2.83 | 10.1 | 1.9 |
| Spec. Industrial | 1,895 | 3,630 | 1.92 | 85.4 | 36.8 |
| Newsprint | 628 | 498 | 0.79 | 185.2 | 248.7 |
| Coated Printing | 1,013 | 1,741 | 1.72 | 448.4 | 309.0 |
| Uncoated Freesheet | 930 | 1,440 | 1.55 | 1,152.6 | 138.6 |
| Uncoated Groundwood | 616 | 1,724 | 2.80 | 139.5 | 104.1 |
| Thin Papers | 1,343 | 1,567 | 1.17 | 51.0 | 9.1 |
| Solid Bl. Bristols | 1,161 | 884 | .76 | 90.3 | 8.1 |
| Cotton Fibre | 908 | 9,903 | 10.91 | 22.4 | 1.8 |
| Tissue | 1,402 | 5,373 | 3.83 | 1,024.0 | 72.9 |
| Board | | | | | |
| Unbl. Kraft Liner. | 643 | 152 | 0.24 | 435.5 | 270.0 |
| Bl. Kraft Liner. | 1,093 | - 848 | -0.78 | - 20.0 | 3.7 |
| Bl. Kraft Folding | 1,090 | 975 | .90 | 83.0 | 49.1 |
| Semi-Chem. Corr. | 545 | 445 | .82 | 134.4 | 138.4 |
| Recycled Liner | 288 | 350 | 1.22 | 8.6 | 0.4 |
| Recycled Corr. | 320 | 540 | 1.69 | 46.0 | 15.4 |
| Recycled Folding | 339 | 1,993 | 5.88 | 130.9 | 19.0 |
| Constr. Paper & Bd. | 267 | 1,391 | 5.21 | 248.1 | 19.5 |
| Molded Pulp | -- | -- | -- | -- | -- |
| Solid Bl. Board | 1,161 | 1,317 | 1.14 | 153.7 | 23.2 |
| All Other Board | 464 | 1,485 | 3.20 | 395.4 | 46.9 |
| Pulp | | | | | |
| Dissolving | 700 | 287 | 0.41 | 33.2 | 0 |
| Market | 399 | -- | -- | -- | -- |
| Total | | | | 5,025.3 | 1,632.2 |

Source: Meta Systems estimates

1979-80.* Similarly, Bleached Foldingboard and Bleached Linerboard capacity utilization will remain in the low eighties with low rates of capacity growth.

Although current forecasts for Newsprint are for somewhat slower growth than in the 70's, prospects are still bright, since U.S. production is only a fraction of domestic demand. Capacity utilization should remain in the mid-90's. This suggests that the unit capital costs for Newsprint derived from the 308 Survey may be overestimated.

Table 7-21 also shows that the following sectors show cash flow less than base expansion costs: Bleached Kraft Papers, Newsprint, Bleached Kraft Linerboard, and Semi-Chemical Corrugating. These results are consistent with the present value analysis and stem from the same causes. Bleached Kraft Papers and Bleached Kraft Linerboard show negative cash flow. For the industry as a whole cash flow is $5,023.5 million and base capital costs for expansion over $1,632.2 million.

## Proposed Regulation

Table 7-22 gives the results of the capital availability analysis for the pollution control capital costs resulting from the Proposed Regulation. Overall, the results are similar to the base case. Capital costs of compliance through 1982 are $1,258.5 million and the cost of new capacity is $1,732.8 million. (Recall that expansion costs include pollution control for new capacity).

The present value of new investment is actually higher than in the base case in most sectors. This result arises when the pollution cost increases are higher for high variable production cost mills than for low variable cost mills. Since price increases are determined by the cost changes of the high cost mills, the price changes in some cases exceed the cost increases for low capacity mills, thereby making them more profitable.

In addition to the product sectors identified in the base case, the following sectors have cash flow less than capital costs of pollution control and expansion: Uncoated Groundwood, Bleached Kraft Foldingboard and Unbleached Kraft Linerboard. The excess of capital costs over cash flow for Unbleached Kraft Linerboard is about 15 percent, and less than one percent for Uncoated Groundwood.

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*DRI Pulp and Paper Review, June 1980, p. 48.

## Table 7-22: Capital Availability Analysis: Proposed Regulation

| | Present Value of -Unit of New Capacity- 1982 | | Internal Funds ---Millions of 1978 $--- | | |
|---|---|---|---|---|---|
| | Net PV | Net PV / Capital Cost | Total Cash Flow, 1982 | BAT Capital Costs Through 1982 | Expansion Cost 1982 |
| **Paper** | | | | | |
| Unbleached Kraft | 607 | .98 | 195.4 | 62.4 | 109.5 |
| Bleached Kraft | - 605 | - .50 | - 27.7 | 24.7 | 13.3 |
| Glassine | 6,704 | 8.07 | 10.1 | 6.7 | 1.9 |
| Spec. Industrial | 3,684 | 1.94 | 85.4 | 9.9 | 36.9 |
| Newsprint | 596 | .95 | 185.2 | 98.6 | 268.8 |
| Coated Printing | 2,294 | 2.27 | 448.4 | 98.1 | 324.8 |
| Uncoated Freesheet | 1,486 | 1.60 | 1,152.6 | 177.8 | 149.8 |
| Uncoated Groundwood | 1,733 | 2.81 | 139.5 | 28.6 | 111.5 |
| Thin Papers | - 651 | - .49 | 51.0 | 12.0 | 9.2 |
| Solid Bl. Bristols | 922 | .79 | 90.3 | 17.6 | 8.3 |
| Cotton Fibre | 10,206 | 11.24 | 22.4 | 3.8 | 1.8 |
| Tissue | 5,402 | 3.85 | 1,024.0 | 99.6 | 77.1 |
| **Board** | | | | | |
| Unbl. Kraft Liner. | 205 | .32 | 435.5 | 185.5 | 287.2 |
| Bl. Kraft Liner. | - 767 | - .70 | - 20.0 | 3.4 | 3.8 |
| Bl. Kraft Folding | 1,133 | 1.04 | 83.0 | 51.7 | 51.0 |
| Semi-Chem. Corr. | 496 | .91 | 134.0 | 68.1 | 148.9 |
| Recycled Liner | 348 | 1.21 | 8.6 | 2.0 | 0.4 |
| Recycled Corr. | 574 | 1.79 | 46.0 | 3.0 | 15.6 |
| Recycled Folding | 1,995 | 5.89 | 130.9 | 7.8 | 19.3 |
| Constr. Paper & Bd. | 1,402 | 5.25 | 248.1 | 6.1 | 20.6 |
| Molded Pulp† | --- | --- | --- | 1.0 | 0 |
| Solid Bl. Board | - 644 | - .55 | 153.7 | 36.6 | 24.4 |
| All Other Board | 559 | 1.53 | 395.4 | 11.9 | 48.2 |
| **Pulp** | | | | | |
| Dissolving | 2,096 | 3.00 | 33.2 | 16.3 | 0 |
| Market† | --- | --- | --- | 221.3 | †† |
| **Total** | | | 5025.3 | 1083.7 | 1732.8 |

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Source: Meta Systems estimates.

†No demand/supply model.

††Included in paper and board expansion costs.

### Alternative Option 1

Table 7-23 shows the results of the capital availability analysis for Alternative Option 1. Total capital costs for pollution control are $811.4 million and capital costs for capacity expansion are $1,727 million.

Of the present values of net investment, those for Bleached Kraft Papers and Bleached Kraft Linerboard are negative. Those with relatively low values are the same ones as for the Proposed Regulation. Overall, the present values are slightly lower for almost all sectors relative to those for the Proposed Regulation.

In the cash flow analysis, one sector which had cash flow less than capital costs under the Proposed Regulation, Bleached Kraft Foldingboard, has net income greater than capital costs under Alternative Option 1. In general, capital costs for existing sources are substantially less than those for the Proposed Regulation.

### Alternative Option 2

Table 7-24 shows the results of the capital availability analysis for Alternative Option 2. Capital costs of pollution control are $1,628.8 million and capital costs of new capacity are $1,733.9 million, somewhat higher than the figures for the Proposed Regulation.

The present values of new capacity are roughly the same as those for the Proposed Regulation, with present values for most sectors slightly lower under Alternative Option 2.

The sectors with cash flow less than total capital costs are the same as those under the Proposed Regulation, and the actual amounts are similar in magnitude.

### Alternative Option 3

Table 7-25 shows the results of the capital availability analysis for Alternative Option 3. Pollution control capital costs are $2,183.2 million (73 percent greater than for the Proposed Regulation) and expansion costs are $1,739.2 million (only slightly higher than for the Proposed Regulation). Both Bleached Kraft Linerboard and Bleached Kraft Foldingboard have negative net present values of new capacity. Present values for other product sectors are slightly less than under the Proposed Regulation.

In addition to those sectors identified in the base case and the Proposed Regulation, Coated Printing Paper and Glassine and Greaseproof also have capital costs greater than cash flow. Capital costs of pollution control for Dissolving Pulp are four time cash flow in that sector.

## Table 7-23. Capital Availability Analysis: Alternative Option 1

| | Present Value of ---Unit of New Capacity--- 1982 | | | Internal Funds --Millions of 1978 $-- | |
|---|---|---|---|---|---|
| **Paper** | Net PV ($/ton) | Net PV Capital Cost | Total Cash Flow 1982 | BAT Capital Costs Through 1982 | Expansion Cost 1982 |
| Unbleached Kraft | 570 | 0.93 | 195.4 | 23.0 | 109.5 |
| Bleached Kraft | - 663 | - 0.55 | - 27.7 | 9.6 | 13.2 |
| Glassine | 2,293 | 2.76 | 10.1 | 4.7 | 1.9 |
| Spec. Industrial | 3,583 | 1.89 | 85.4 | 8.0 | 37.0 |
| Newsprint | 461 | 0.74 | 185.2 | 60.1 | 268.1 |
| Coated Printing | 1,703 | 1.68 | 448.4 | 74.4 | 323.6 |
| Uncoated Freesheet | 1,388 | 1.49 | 1,152.6 | 124.4 | 148.9 |
| Uncoated Groundwood | 1,693 | 2.75 | 139.5 | 17.5 | 110.4 |
| Thin Papers | 1,516 | 1.13 | 51.0 | 5.8 | 9.3 |
| Solid Bl. Bristols | 842 | 0.73 | 90.3 | 6.9 | 8.2 |
| Cotton Fibre | 9,853 | 10.85 | 22.4 | 0.6 | 1.8 |
| Tissue | 5,320 | 3.80 | 1,024.0 | 60.7 | 77.1 |
| **Board** | | | | | |
| Unbl. Kraft Liner. | 135 | 0.21 | 435.5 | 94.2 | 286.6 |
| Bl. Kraft Liner. | - 885 | - 0.81 | - 20.0 | 1.0 | 3.8 |
| Bl. Kraft Folding | 984 | 0.90 | 83.0 | 21.2 | 50.3 |
| Semi-Chem. Corr. | 407 | 0.75 | 134.4 | 57.7 | 148.9 |
| Recycled Liner | 603 | 2.09 | 8.6 | 1.0 | 0.4 |
| Recycled Corr. | 517 | 1.62 | 46.0 | 2.4 | 15.5 |
| Recycled Folding | 1,980 | 5.84 | 130.9 | 2.3 | 19.1 |
| Constr. Paper & Bd. | 1,357 | 5.08 | 248.1 | 7.9 | 20.9 |
| Molded Pulp[††] | -- | -- | -- | 2.8 | 0 |
| Solid Bl. Board | 1,284 | 1.11 | 153.7 | 19.2 | 24.2 |
| All Other Board | 1,470 | 3.17 | 395.4 | 5.4 | 47.9 |
| **Pulp** | | | | | |
| Dissolving | 405 | .58 | 33.2 | 88.5 | 0[†] |
| Market[††] | -- | -- | -- | 112.1 | |
| **Total** | | | 5,025.3 | 811.4 | 1,727.0 |

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Source: Meta Systems estimates

[†] Included in paper and board expansion costs.

[††] No demand/supply model.

### Table 7-24. Capital Availability Analysis: Alternative Option 2

|  | Present Value of ---Unit of New Capacity--- 1982 |  | Internal Funds --Millions of 1978 $-- |  |  |
|---|---|---|---|---|---|
| Paper | Net PV ($/ton) | Net PV Capital Cost | Total Cash Flow 1982 | BAT Capital Costs Through 1982 | Expansion Cost 1982 |
| Unbleached Kraft | 529 | 0.86 | 195.4 | 70.2 | 109.5 |
| Bleached Kraft | - 679 | - 0.57 | - 27.7 | 25.8 | 13.3 |
| Glassine | 2,260 | 2.72 | 10.1 | 9.7 | 2.0 |
| Spec. Industrial | 3,513 | 1.85 | 85.4 | 14.3 | 37.4 |
| Newsprint | 416 | 0.66 | 185.2 | 144.9 | 269.1 |
| Coated Printing | 1,638 | 1.62 | 448.4 | 118.1 | 324.2 |
| Uncoated Freesheet | 1,331 | 1.43 | 1,152.6 | 215.9 | 149.2 |
| Uncoated Groundwood | 1,624 | 2.64 | 139.5 | 38.5 | 111.9 |
| Thin Papers | 1,448 | 1.08 | 51.0 | 15.6 | 9.3 |
| Solid Bl. Bristols | 771 | 0.66 | 90.3 | 21.0 | 8.3 |
| Cotton Fibre | 9,853 | 10.85 | 22.4 | 0.8 | 1.8 |
| Tissue | 5,244 | 3.74 | 1,024.0 | 126.4 | 77.2 |
| Board |  |  |  |  |  |
| Unbl. Kraft Liner. | 80 | 0.12 | 435.5 | 245.5 | 287.6 |
| Bl. Kraft Liner. | - 929 | - 0.85 | - 20.0 | 12.7 | 3.8 |
| Bl. Kraft Folding | 979 | 0.90 | 83.0 | 66.5 | 15.0 |
| Semi-Chem. Corr. | 418 | 0.77 | 134.4 | 98.0 | 149.2 |
| Recycled Liner | 583 | 2.02 | 8.6 | 3.8 | 0.4 |
| Recycled Corr. | 536 | 1.68 | 46.0 | 5.9 | 15.5 |
| Recycled Folding | 1,971 | 5.82 | 130.9 | 4.8 | 19.4 |
| Constr. Paper & Bd. | 1,376 | 5.15 | 248.1 | 19.8 | 21.1 |
| Molded Pulp †† | -- | -- | -- | 2.8 | 0 |
| Solid Bl. Board | 1,252 | 1.08 | 153.7 | 48.6 | 24.4 |
| All Other Board | 1,464 | 3.16 | 395.4 | 14.7 | 48.3 |
| Pulp |  |  |  |  |  |
| Dissolving | 444 | 0.63 | 33.2 | 75.6 | 0 |
| Market†† | -- | -- | -- | 235.6 | † |
| Total |  |  | 5,025.3 | 1628.8 | 1733.9 |

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Source: Meta Systems estimates

†Included in paper and board expansion costs.

††No demand/supply model.

## Table 7-25. Capital Availability Analysis: Alternative Option 3

| | Present Value of ---Unit of New Capacity--- 1982 | | | Internal Funds --Millions of 1978 $-- | |
|---|---|---|---|---|---|
| | Net PV ($/ton) | Net PV Capital Cost | Total Cash Flow 1982 | BAT Capital Costs Through 1982 | Expansion Cost 1982 |
| **Paper** | | | | | |
| Unbleached Kraft | 538 | 0.88 | 195.4 | 84.6 | 109.5 |
| Bleached Kraft | - 686 | 0.57 | - 27.7 | 33.0 | 13.4 |
| Glassine | 2,397 | 2.88 | 10.1 | 12.6 | 2.0 |
| Spec. Industrial | 3,544 | 1.87 | 85.4 | 17.7 | 37.5 |
| Newsprint | 476 | .76 | 185.2 | 152.6 | 269.4 |
| Coated Printing | 1,688 | 1.67 | 448.4 | 174.5 | 325.5 |
| Uncoated Freesheet | 1,391 | 1.50 | 1,152.6 | 306.2 | 150.0 |
| Uncoated Groundwood | 1,637 | 2.66 | 139.5 | 44.8 | 112.4 |
| Thin Papers | 1,510 | 1.13 | 51.0 | 25.9 | 9.4 |
| Solid Bl. Bristols | 674 | — 0.58 | 90.3 | 29.1 | 8.4 |
| Cotton Fibre | 9,756 | 10.74 | 22.4 | 0.7 | 1.9 |
| Tissue | 5,205 | 3.71 | 1,024.0 | 146.3 | 77.2 |
| **Board** | | | | | |
| Unbl. Kraft Liner. | 106 | 0.17 | 435.5 | 310.6 | 287.8 |
| Bl. Kraft Liner. | - 872 | - 0.80 | - 20.0 | 3.5 | 3.8 |
| Bl. Kraft Folding | 975 | 0.90 | 83.0 | 84.0 | 51.2 |
| Semi-Chem. Corr. | 439 | 0.81 | 134.4 | 130.9 | 149.5 |
| Recycled Liner | 276 | 0.96 | 8.6 | 8.1 | 0.4 |
| Recycled Corr. | 510 | 1.59 | 46.0 | 11.7 | 15.9 |
| Recycled Folding | 1,954 | 5.76 | 130.9 | 14.8 | 19.6 |
| Constr. Paper & Bd. | 1,359 | 5.09 | 248.1 | 25.6 | 21.2 |
| Molded Pulp†† | -- | -- | -- | 4.4 | 0 |
| Solid Bl. Board | 1,172 | 1.01 | 153.7 | 61.7 | 24.4 |
| All Other Board | 1,439 | 3.10 | 395.4 | 14.5 | 48.7 |
| **Pulp** | | | | | |
| Dissolving | 402 | 0.57 | 33.2 | 163.7 | 0 |
| Market†† | -- | -- | -- | 318.8 | † |
| **Total** | | | 5,025.3 | 2183.2 | 1739.3 |

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Source: Meta Systems estimates

†Included in paper and expansion costs.

††No demand/supply model.

### Alternative Option 4

Table 7-26 shows the results of the capital availability analysis for Alternative Option 4. Total capital costs of pollution control are $1,332.7 million and capital costs of expansion are $1,733.8 million. The results are identical to those for the Proposed Regulation except for Dissolving Pulp and Construction Paper and Board. For Construction Paper and Board, the present value is slightly lower than under the Proposed Regulation, and capital costs are 2.5 times as high. For Dissolving Pulp, the present value is slightly lower, and capital costs are over 2.5 times as high as annual cash flow.

### Mill-Specific Capital Availability

The cash flow analysis described above focuses on the overall amount of funds in each product sector available to finance investments in pollution control. Examining such broad aggregates may overlook potential capital problems that individual mills within a product sector may face. Table 7-27 presents the results of the mill-specific capital availability analysis described in Section 2 for each subcategory. The table shows the number of mills in each subcategory whose BCT/BAT pollution control investment costs exceed their annual cash flow based on 1983-85 prices. These results are further broken down into three ranges for the ratio of investment cost to cash flow 1.0 to 1.5; 1.5 to 2.0, and greater than 2.0. The measure of cash flow is the more conservative one from which normal reinvestment costs are deducted. (See Section 2.)

Under the Proposed Regulation, 56 mills have investment costs greater than one-year cash flows, and 26 mills have investment costs twice as great as cash flow. Thirty-six out of the 56 mills are in integrated mill subcategories, reflecting the higher costs of compliance in those subcategories. Mills which are classified as likely base closures (see next part of this section) had a slightly greater tendency than all mills to have a ratio greater than one, but the difference is not significant. On the other hand, all mills classified as treatment-related closures had ratios greater than one.

The results for Alternative Options 1-4 present the same general pattern as those for the Proposed Regulation. The number of mills with ratios greater than one varies with the stringency of the option in an expected way. The lowest number of affected mills occurs under Alternative Option 1 and the highest number occurs under Alternative Option 3. The results for Alternative Options 2 and 4 are fairly close to those for the Proposed Regulation.

It must be repated that the results given here are only a rough indicator of problems of capital availability. Most mills will be able

## Table 7-26. Capital Availability Analysis
## Alternative Option 4

| | Present Value of -Unit of New Capacity- 1982 | | Internal Funds -Millions of 1978 $- | | |
|---|---|---|---|---|---|
| **Paper** | **Net PV** | **Net PV Capital Cost** | **Total Cash Flow, 1982** | **BAT Capital Costs Through 1982** | **Expansion Cost 1982** |
| Unbleached Kraft | 607 | .98 | 195.4 | 62.4 | 109.5 |
| Bleached Kraft | - 605 | - .50 | - 27.7 | 24.7 | 13.3 |
| Glassine | 6,704 | 8.07 | 10.1 | 6.7 | 1.9 |
| Spec. Industrial | 3,684 | 1.94 | 85.4 | 9.9 | 36.9 |
| Newsprint | 596 | .95 | 185.2 | 98.6 | 268.8 |
| Coated Printing | 2,294 | 2.27 | 448.4 | 98.1 | 324.8 |
| Uncoated Freesheet | 1,486 | 1.60 | 1,152.6 | 177.8 | 149.8 |
| Uncoated Groundwood | 1,733 | 2.81 | 139.5 | 28.6 | 111.5 |
| Thin Papers | - 651 | - .49 | 51.0 | 12.0 | 9.2 |
| Solid Bl. Bristols | 922 | .79 | 90.3 | 17.6 | 8.3 |
| Cotton Fibre | 10,206 | 11.24 | 22.4 | 3.8 | 1.8 |
| Tissue | 5,402 | 3.85 | 1,024.0 | 99.6 | 77.1 |
| **Board** | | | | | |
| Unbl. Kraft Liner. | 205 | .32 | 435.5 | 185.5 | 287.2 |
| Bl. Kraft Liner. | - 767 | - .70 | - 20.0 | 3.4 | 3.8 |
| Bl. Kraft Folding | 1,133 | 1.04 | 83.0 | 51.7 | 51.0 |
| Semi-Chem. Corr. | 496 | .91 | 134.0 | 68.1 | 148.9 |
| Recycled Liner | 348 | 1.21 | 8.6 | 2.0 | 0.4 |
| Recycled Corr. | 574 | 1.79 | 46.0 | 3.0 | 15.6 |
| Recycled Folding | 1,995 | 5.89 | 130.9 | 7.8 | 19.3 |
| Constr. Paper & Bd. | 1,295 | 4.85 | 248.1 | 15.0 | 21.6 |
| Molded Pulp† | --- | --- | --- | 1.0 | 0 |
| Solid Bl. Board | - 644 | - .55 | 153.7 | 36.6 | 24.4 |
| All Other Board | 559 | 1.53 | 395.4 | 11.9 | 48.2 |
| **Pulp** | | | | | |
| Dissolving | 1,993 | 2.85 | 33.2 | 81.6 | 0 |
| Market† | --- | --- | --- | 221.3 | †† |
| **Total** | | | 5025.3 | 1,332.7 | 1,733.8 |

Source: Meta Systems estimates.

†No demand/supply model.

††Included in paper and board expansion costs.

TABLE 7-27. Comparison of BCT/BAT Investment Costs and Annual Cash Flows of Individual Mills by Major Subcategory Type

| Total Number of Direct Dischargers = 347 | Number of Mills with Ratio of Investment Costs to Cash Flow Within Each Percentage Range | | | |
|---|---|---|---|---|
| | 100-150% | 150-200% | >200% | Total |
| Proposed Regulation | | | | |
| Integrated | 13 | 8 | 15 | 36 |
| Secondary Fiber | 3 | 4 | 7 | 14 |
| Nonintegrated | 0 | 2 | 4 | 6 |
| Total | 16 | 14 | 26 | 56 |
| Alternative Option 1 | | | | |
| Integrated | 5 | 4 | 12 | 21 |
| Secondary Fiber | 4 | 2 | 4 | 10 |
| Nonintegrated | 2 | 1 | 3 | 6 |
| Total | 11 | 7 | 19 | 37 |
| Alternative Option 2 | | | | |
| Integrated | 19 | 10 | 16 | 45 |
| Secondary Fiber | 3 | 2 | 7 | 12 |
| Nonintegrated | 4 | 1 | 5 | 10 |
| Total | 26 | 13 | 28 | 67 |
| Alternative Option 3 | | | | |
| Integrated | 22 | 16 | 26 | 64 |
| Secondary Fiber | 3 | 2 | 11 | 16 |
| Nonintegrated | 6 | 2 | 5 | 13 |
| Total | 31 | 20 | 42 | 93 |
| Alternative Option 4 | | | | |
| Integrated | 14 | 8 | 18 | 40 |
| Secondary Fiber | 3 | 5 | 9 | 17 |
| Nonintegrated | 0 | 2 | 4 | 6 |
| Total | 17 | 15 | 31 | 63 |

Source: Meta Systems estimates.

to spread investment costs over a number of years by selling industrial revenue bonds. Multi-mill firms may be able to shift funds from other mills to those mills with the highest investment costs.

## Mill Closure Analysis

This subsection gives the results of the mill closure analysis. As was discussed in the methodology in Section 2, the analysis represents only an approximation of the actual closure decision rule and information used to make that decision. Nevertheless, use of the 308 Survey probably gives as accurate and detailed a financial picture of the industry as can be obtained. Table 7-28 shows estimated numbers of mill closures and total losses of capacity by major subcategory group for the Base Case as well as the changes in closures resulting from the cost and price impacts of the Proposed Regulation. Fifty-seven out of a total of 587 mills close in the base case. Seven more mills are predicted to close under the Proposed Regulation, and another four mills that were projected Base Case closures stay open, making net closures due to the Proposed Regulation equal to plus three. This occurs because indirect discharger mills or mills with low treatment costs benefit from the price increases brought about by mills with higher cost increases. The overall amount of capacity lost is 3.15 million tons per year in the Base Case, with a net gain of 210,000 tons per year under the Proposed Regulation.

Nonintegrated mills show the greatest relative number of base closures with 26 out of 135 mills closing. Twenty-five out of 247 secondary fiber mills close, while integrated mills have the fewest closures, both in absolute and percentage terms: six out of 205.

The distribution of closures and closed capacity across the major product sector groupings (Pulp, Paper, Paperboard) is shown in Table 7-29. By far the largest number of closures occur in mills producing paper grades. It should be noted that the number of closures is in some cases greater here than in Table 7-28 because of double-counting, since some mills produce both paper and board. For comparison, the total average amount of slack capacity over the period 1983-85 implied by the demand/supply analysis is also shown in Table 7-29. To be consistent, the amount of slack capacity should exceed the amount of closed capacity by a fair amount since not all remaining mills will run at full capacity. Overall the amount of slack capacity is 480,000 tons per year while the amount of net closed capacity is negative, so this simple consistency test is met.

The relationship between closed capacity and slack capacity for the increments to each due to treatment costs is less obvious. For example, a mill which had low capacity utilization in the base case but just managed to stay open might close because of treatment costs.

Table 7-28. Results of Mill Closure Analysis By Subcategory Group: Base Case and Proposed Regulation

| | Integrated Mills | Secondary Fiber Mills | Nonintegrated Mills | Total |
|---|---|---|---|---|
| **Base Case** | | | | |
| No. Closures | 6 | 25 | 26 | 57 |
| Capacity Closed (000 tons/year) | 1031 | 851 | 1269 | 3151 |
| No. Mills In Sample | 205 | 247 | 135 | 587 |
| Proposed Regulation (Additional Impacts) | | | | |
| No. Closures | 1 | 5 | 1 | 7 |
| No. Reopenings | 1 | 2 | 1 | 4 |
| Capacity Closed (000 tons/year) | -102 | 66 | -174 | -210 |

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Source: Meta Systems estimates

### Table 7-29. Results of Mill Closure Analysis by Product Group, Base Case and Proposed Regulation

| | Pulp | Paper | Board | Total |
|---|---|---|---|---|
| Base Case | | | | |
| No. Closures | 5 | 46 | 12 | 63 |
| Capacity Closed (000 tons/year) | 186 | 2433 | 532 | 3151 |
| Slack Capacity (000 tons/year) | 145 | 2156 | 6138 | 7719 |
| Proposed Regulation (Additional Impacts) | | | | |
| No. Closures | 0 | 4 | 3 | 7 |
| No. Reopenings | 1 | 1 | 2 | 4 |
| Capacity Closed (000 tons/year) | -184 | -66 | 40 | -210 |
| Slack Capacity (000 tons/year) | 30 | 144 | 307 | 481 |

---

Source: Meta Systems estimates

Therefore, when treatment costs are imposed, not only is overall production reduced, but it is reallocated among mills if some close. Therefore, the consistency test should compare total slack capacity with total closed capacity. Again, Table 7-29 shows that this test is met for the industry as a whole with an ample margin.

Tables 7-30 and 7-31 show the results of the closure analysis for the four alternative options by major subcategory and product sector group, respectively. The highest number of closures occurs under Alternative Option 4, with nine added closures. The greatest loss of capacity occurs under the most costly option, Alternative Option 3, with an added 333,000 tons per year closed. The lowest impacts occur under Alternative Option 1, the least costly option, with two closures and three reopenings for a net gain in capacity of 184,000 tons per year.

Table 7-32 shows the breakdown of potential closures by region for the Base Case, the Proposed Regulation and the Alternative Options. Base Case closures are heavily concentrated in the Northeast and North Central regions (45 out of 57 mills). This result is consistent with the concentration of smaller older nonintegrated mills in these regions. The closures and reopenings under the treatment options occur mostly in the Northeast, Southeast and North Central areas.

It is important to verify the forecast of base closures, because it is possible that overestimating the number of base closures could lead to an underestimation of closures due to treatment costs. The number of base closures seems high but is not out of line when compared with previous years or with projected market conditions in various sectors. According to API,* 56 mills closed in the period 1970-75, 14 mills in 1976-77, and 9 mills in 1978-79. In comparison, our analysis covers the period 1978-85.

Market conditions in a number of product sectors make a number of closures likely. Typically, smaller, older nonintegrated mills will be vulnerable to a combination of significant increases in new integrated capacity and recession-weakened demand in the early 1980's. This situation should occur in Tissues,** Coated Printing and Uncoated Freesheet,*** and Unbleached Linerboard. In addition, closures can be

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*API Capacity Estimate, 1979.

**Pulp and Paper, March 1980, p. 17.

***Ibid., August 1980, p. 125.

Table 7-30. Results of Mill Closure Analysis, by Subcategory Group
Alternative Options 1-4

| | Integrated Mills | Secondary Fiber Mills | Nonintegrated Mills | Total |
|---|---|---|---|---|
| Alternative Option 1 | | | | |
| No. Closures | 0 | 1 | 1 | 2 |
| No. Reopenings | 0 | 2 | 1 | 3 |
| Capacity Closed (000 tons/year) | 0 | -19 | -165 | -184 |
| Alternative Option 2 | | | | |
| No. Closures | 2 | 3 | 0 | 5 |
| No. Reopenings | 0 | 0 | 1 | 1 |
| Capacity Closed (000 tons/year) | 144 | 56 | -30 | 170 |
| Alternative Option 3 | | | | |
| No. Closures | 4 | 2 | 0 | 6 |
| No. Reopenings | 0 | 0 | 2 | 2 |
| Capacity Closed (000 tons/year) | 482 | 26 | -175 | 333 |
| Alternative Option 4 | | | | |
| No. Closures | 1 | 7 | 1 | 5 |
| No. Reopenings | 0 | 2 | 1 | 3 |
| Capacity Closed (000 tons/year) | 83 | 93 | -174 | 2 |

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Source: Meta Systems estimates

Table 7-31. Results of Mill Closure Analysis, by Product Group
Alternative Options 1-4

| | Pulp | Paper | Paperboard | Total |
|---|---|---|---|---|
| Alternative Option 1 | | | | |
| No. Closures | 0 | 2 | 0 | 2 |
| No. Reopenings | 0 | 1 | 2 | 3 |
| Capacity Closed (000 tons/year) | 0 | -161 | -23 | -184 |
| Slack Capacity (000 tons/year) | 15 | 186 | 412 | 613 |
| Alternative Option 2 | | | | |
| No. Closures | 0 | 4 | 1 | 5 |
| No. Reopenings | 0 | 1 | 0 | 1 |
| Capacity Closed (000 tons/year) | 0 | 140 | 30 | 170 |
| Slack Capacity (000 tons/year) | 3 | 159 | 226 | 388 |
| Alternative Option 3 | | | | |
| No. Closures | 2 | 4 | 1 | 5 |
| No. Reopenings | 0 | 2 | 1 | 4 |
| Capacity Closed (000 tons/year) | 280 | 54 | -1 | 333 |
| Slack Capacity (000 tons/year) | 1 | 43 | 53 | 97 |
| Alternative Option 4 | | | | |
| No. Closures | 0 | 4 | 5 | 9 |
| No. Reopenings | 0 | 1 | 2 | 3 |
| Capacity Closed (000 tons/year) | 0 | -65 | -67 | 2 |
| Slack Capacity (000 tons/year) | 56 | 144 | 307 | 507 |

Source: Meta Systems estimates

## Table 7-32. Projected Net Mill Closures by Region

|  | Northeast | Southeast | North Central | Northwest | West & Southwest |
|---|---|---|---|---|---|
| Base Case |  |  |  |  |  |
| No. Mills | 27 | 3 | 18 | 2 | 7 |
| Capacity Closed (000 tons/year) | 1543 | 103 | 931 | 212 | 363 |
| Additional Impacts: |  |  |  |  |  |
| Proposed Regulation |  |  |  |  |  |
| No. Mills | 1 | 3 | 2 | -1 | 0 |
| Capacity Closed (000 tons/year) | -149 | 18 | 104 | -183 | 0 |
| Alternative Option 1 |  |  |  |  |  |
| No. Mills | -2 | 0 | 1 | 0 | 0 |
| Capacity Closed (000 tons/year) | -196 | 0 | 12 | 0 | 0 |
| Alternative Option 2 |  |  |  |  |  |
| No. Mills | 3 | 0 | 1 | 0 | 0 |
| Capacity Closed (000 tons/year) | 95 | 0 | 75 | 0 | 0 |
| Alternative Option 3 |  |  |  |  |  |
| No. Mills | 3 | 1 | -1 | 1 | 0 |
| Capacity Closed (000 tons/year) | 206 | 103 | -153 | 177 | 0 |
| Alternative Option 4 |  |  |  |  |  |
| No. Mills | 1 | 3 | 2 | 0 | 2 |
| Capacity Closed (000 tons/year) | -149 | 18 | 105 | 0 | 27 |

Source: Meta Systems estimates

expected to be concentrated in the secondary fiber and nonintegrated mills because they will be caught in a squeeze due to market pulp prices rising faster than the wood prices faced by the integrated mills.*

## Employment Impacts of Mill Closures

Table 7-33 shows the direct effects of the projected mill closures on employment. Under the Proposed Regulation, there is a net gain of 600 jobs. The highest employment losses occur under Alternative Option 3 with 3200 jobs lost overall and the next highest impacts are under Alternative Option 2 with 2500 jobs lost. The lowest employment impacts occur under the least costly option, Alternative Option 1, with a net gain of 750 jobs.

As was noted in Section 2, the above methodology for determining employment impacts examines only impacts due to mill closures rather than any reductions in output. The impact of reductions in output on the number of jobs is more difficult to predict. It is likely that mills would reduce overtime and the number of shifts rather than simply reduce the number of full-time jobs in proportion to the reduction in output. This suggests that applying an average productivity figure to the reduction in output caused by treatment costs will overestimate the number of jobs lost. However, more accurate information is not available. As a supplement to the impacts of closure on employment, employment losses under each treatment option were also estimated by multiplying output losses in each product sector by average worker per ton figures derived from the 308 Survey. The results are as follows:

|  | Number of Jobs Lost |
|---|---|
| Proposed Regulation | 1418 |
| Alternative Option 1 | 335 |
| Alternative Option 2 | 1287 |
| Alternative Option 3 | 1951 |
| Alternative Option 4 | 1517 |

In some cases these numbers are less than from the closure impacts alone. This is because some mills will increase output to absorb some of the output lost by the closed mills. Note also that this analysis does not capture increases in output in other industries due to substitution resulting from higher prices of pulp and paper products.

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*Paper Trade Journal, March 15, 1980, p. 29.

## TABLE 7-33. Direct Losses in Employment Due to Mill Closures

| | Number of Jobs | | |
|---|---|---|---|
| | Mill Closures | Mill Reopenings | Total |
| Proposed Regulation | | | |
| Integrated | 650 | - 650 | 0 |
| Secondary Fiber | 400 | - 150 | 250 |
| Nonintegrated | 50 | - 900 | -850 |
| Total | 1100 | -1700 | -600 |
| Alternative Option 1 | | | |
| Integrated | 0 | 0 | 0 |
| Secondary Fiber | 0 | 0 | 0 |
| Nonintegrated | 150 | - 900 | -750 |
| Total | 150 | - 900 | -750 |
| Alternative Option 2 | | | |
| Integrated | 2350 | 0 | 2350 |
| Secondary Fiber | 150 | 0 | 150 |
| Nonintegrated | 0 | 0 | 0 |
| Total | 2500 | 0 | 2500 |
| Alternative Option 3 | | | |
| Integrated | 3050 | 0 | 3050 |
| Secondary Fiber | 150 | 0 | 150 |
| Nonintegrated | 0 | 0 | 0 |
| Total | 3200 | 0 | 3200 |
| Alternative Option 4 | | | |
| Integrated | 650 | 0 | 650 |
| Secondary Fiber | 500 | - 150 | 350 |
| Nonintegrated | 50 | - 900 | -850 |
| Total | 1200 | -1050 | 150 |

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Source: Meta Systems estimates, E.C. Jordan 308 Survey Data

## Community Impacts

Because of the confidentiality of the 308 Survey data, it was not possible to identify specific communities which would be affected by the predicted mill closures under the Proposed Regulation and the Alternative Options. However, a methodology for determining indirect impacts on earnings and employment which takes regional variations in wage rates into account was described in Section 2. This section presents the results of that methodology along with the direct impacts on earnings. As discussed in Section 2, it was not possible to estimate losses in state and federal tax revenues due to mill closures. Local revenues from user charges should not be affected because "indirect dischargers" which discharge to publicly-owned treatment works (POTW's) are not affected by the Proposed Regulation.

Table 7-34 shows direct, indirect and total changes in earnings due to the Proposed Regulation and the four Alternative Options. The effects on earnings of mill closures and reopenings are given separately. In some cases the positive effects of the reopenings outweigh the negative effects of the closures. Under the Proposed Regulation, net direct additions to earnings are 46.3 million per year; indirect impacts are $62.9 million per year; and total net impacts are $99.2 million per year. The greatest losses occur under Alternative Option 3, with an overall loss in earnings of $137.6 million per year. It should be noted that these earnings loss estimates assume that discharged workers do not find alternative employment. Therefore these estimates can be expected to decline over time as the workers relocate and/or retrain for other jobs.

Table 7-35 shows indirect impacts on employment. As discussed in Section 2, indirect impacts are calculated by applying regional wage data to the indirect earnings impacts shown in Table 7-34. Net indirect employment gains under the Proposed Regulation are 3400 jobs. The largest negative indirect impacts occur under Alternative Option 2, with 4929 net jobs lost.

### TABLE 7-34. Impacts Due to Mill Closures Direct and Indirect Earnings Losses

Millions of 1978 $

| | Direct | | Indirect | | Net† |
|---|---|---|---|---|---|
| | Closures | Reopenings | Closures | Reopenings | Total |
| Proposed Regulation | | | | | |
| Integrated | 5.0 | -17.0 | 34.1 | - 39.5 | - 17.4 |
| Secondary Fiber | 6.7 | - 2.3 | 14.9 | - 3.5 | 15.8 |
| Nonintegrated | 1.2 | -29.9 | 4.1 | - 73.0 | - 98.8 |
| Total | 12.9 | -49.2 | 53.1 | -116.0 | - 99.2 |
| Alternative Option 1 | | | | | |
| Integrated | 0 | 0 | 0 | 0 | 0 |
| Secondary Fiber | .5 | - 2.3 | 1.0 | - 3.5 | - 4.3 |
| Nonintegrated | 2.9 | -29.9 | 6.2 | - 73.0 | - 93.8 |
| Total | 3.4 | -32.2 | 7.2 | - 76.5 | - 98.1 |
| Alternative Option 2 | | | | | |
| Integrated | 12.5 | 0 | 54.5 | 0 | 67.0 |
| Secondary Fiber | 4.9 | 0 | 11.6 | 0 | 16.5 |
| Nonintegrated | 0 | - 4.2 | 0 | - 20.6 | - 24.8 |
| Total | 17.4 | - 4.2 | 66.1 | - 20.6 | 58.7 |
| Alternative Option 3 | | | | | |
| Integrated | 87.6 | 0 | 156.6 | 0 | 244.2 |
| Secondary Fiber | 3.8 | 0 | 8.5 | 0 | 12.3 |
| Nonintegrated | 0 | -43.9 | 0 | - 75.1 | -119.0 |
| Total | 91.4 | -43.9 | 165.1 | - 75.1 | 137.5 |
| Alternative Option 4 | | | | | |
| Integrated | .2 | 0 | 34.1 | 0 | 34.3 |
| Secondary Fiber | 7.5 | - 2.3 | 17.4 | - 3.5 | 19.1 |
| Nonintegrated | 1.1 | -29.9 | 3.6 | - 73.0 | - 98.2 |
| Total | 8.8 | -32.2 | 55.1 | - 76.5 | - 44.8 |

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Source: Meta Systems estimates

†Sum of all four columns.

### TABLE 7-35. Impacts Due to Mill Closures: Indirect Employment Losses

Number of Jobs Lost

| | Closures | Reopenings | Total |
|---|---|---|---|
| Proposed Regulation | | | |
| Integrated | 1800 | -2200 | - 400 |
| Secondary Fiber | 800 | - 200 | 600 |
| Nonintegrated | 200 | -3800 | -3600 |
| Total | 2800 | -6200 | -3400 |
| Alternative Option 1 | | | |
| Integrated | 0 | 0 | 0 |
| Secondary Fiber | 50 | - 200 | - 150 |
| Nonintegrated | 300 | -3800 | -3500 |
| Total | 350 | -4000 | -3650 |
| Alternative Option 2 | | | |
| Integrated | 2850 | 0 | 2850 |
| Secondary Fiber | 600 | 0 | 600 |
| Nonintegrated | 0 | -1100 | -1100 |
| Total | 3450 | -1100 | 2350 |
| Alternative Option 3 | | | |
| Integrated | 8450 | 0 | 8450 |
| Secondary Fiber | 450 | 0 | 450 |
| Nonintegrated | 0 | -4000 | -4000 |
| Total | 8900 | -4000 | 4900 |
| Alternative Option 4 | | | |
| Integrated | 1800 | 0 | 1800 |
| Secondary Fiber | 950 | - 200 | 750 |
| Nonintegrated | 200 | -3800 | -3600 |
| Total | 2950 | -4000 | -1050 |

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Source: Meta Systems estimates

## Impact on U.S. Balance of Trade

As the world's largest producer of forest products, the United States supplied roughly 35 percent of total world pulp, paper and paperboard in 1979. However, the United States is also the largest consumer of these products, and in 1979 exports were only 45 percent of imports by weight.* U.S. consumption in 1979 was 64.3 million metric tons, which far out-paced second-ranked Japan (17.5 million metric tons), third-ranked West Germany (9.5 million tons), and fourth-ranked USSR (8.4 million tons). This is due in part to our very high per capita consumption of 637 pounds of pulp, paper and paperboard, as compared to Canada's 474, Sweden's 470, and West Germany's 452 pounds per capita. No other country consumed over 400 pounds of forest products per capita last year.

Though the United States clearly dominates world production and consumption of forest products, its rate of production expansion has not kept pace with other parts of the world. Long-term (1960-1978) expansion trends show Asia/Australia leading with an annual rate of production expansion of 11.9 percent, followed by Latin America with 8.1 percent, Europe with 4.3 percent, and North America with 3.5 percent (which tied with Africa for last place world wide). These percent increases, however, ignore the base size on which expansion grows. Thus the North American paper and paperboard tonnage increase from 1960 to 1978 was 32.5 million metric tons, compared to Europe's 30.5 million, Asia's 24.3 million, and Latin America's 4.7 million. According to a recent study by the Food and Agriculture Organization's Pulp and Paper Advisory Board, between 1979 and 1984 world paper and paperboard capacity will grow at an annual rate of 2.9 percent and world papergrade pulp capacity will grow at an annual rate of 2.6 percent.** In spite of an expected 12 percent growth in U.S. world pulp capacity between 1979 and 1984, the study predicts that U.S. pulp capacity will drop from 33.5 percent to 33 percent of world capacity over this same five year period.

The most pronounced world-wide long-term production trend has been the entrenchment of rich countries as dominant forest product producers. Less developed countries currently produce less than one-quarter of the world's paperboard and less than one-fifth of the world's pulp. Though both rates represent developing countries' increases since 1960, North American world dominance will continue for a long time. As an example, two new U.S. mills (Weyerhauser in Mississippi and International Paper in Louisiana) will add almost as much capacity to these companies as Africa's total 1978 production.

Currently imports exceed exports, both in terms of tonnage and value. According to the U.S. Census, in 1978 we exported approximately

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*Pulp and Paper, August 1980, p. 74.

**Paper Trade Journal, August 15, 1980, p. 57.

2.6 million tons of wood pulp valued at $.82 billion, while importing 4.0 million tons valued at $1.1 billion. In the same year, we exported 2.9 million tons of paper and paperboard valued at $1.1 billion, while importing 9.3 million tons valued at $2.7 billion.

Table 7-36 below lists the amounts of various pulp, paper and paperboard products imported and exported by the United States in 1978. In some cases, the categories are slightly different for exports and imports. Among the pulp categories, we both import and export large quantities of Bleached Sulfate Pulp. We also export large amounts of Dissolving Pulp.

United States imports of paper are over three times as large as our exports of paper. Over one-half of all pulp, paper and paperboard imports is Newsprint, chiefly from Canada. We also import significant amounts of Uncoated Printing Paper. In contrast, we export very large quantities of paperboard and import very little. The major export in this category is Kraft Linerboard. To summarize, our major export sectors are Dissolving and Bleached Sulphate Pulp, Kraft Linerboard and Bleached Packaging Paperboard. Our major import sectors are Bleached Sulphate Pulp, Newsprint, Uncoated Printing and Construction Paper and Board.

Future production and consumption levels are projected by the Data Resources, Inc. (DRI) international pulp and paper models in conjunction with their models of the economies of various countries. They expect paper and board demand to increase in response to quickened economic growth in the 1980's. However, paper and board markets will not keep pace with general economic growth in the late 1980's due to rising real prices of paper and increased competition from electronics and alternative packaging methods and materials. Printing and writing papers will lead overall paper and board demand. Imports will become increasingly competitive as tariffs are reduced under the General Agreement on Tariffs and Trade (GATT). Scandinavian exports to Western Europe will retain their most favored status under the European Free Trade Association (EFTA) agreements, with import tariffs on Scandinavian goods being phased out by 1983.

In the early 1980's, demand for pulp will exceed capacity and real prices will increase, leading to new investment in the U.S. South and in non-traditional producing areas of the world. By the late 1980's, the supply will have increased sufficiently to stabilize prices. DRI does not foresee any wood shortage in the U.S. through 1990, even with the large increases in pulp demand they are forecasting.

DRI forecasts that a large portion of the worldwide growth in pulp and paper demand over the next decade will occur in regions which lack the resources necessary to meet this increase. Therefore, rapid increases in pulp and paper products trade on the world market will continue. Two areas of the world which will be the major importers are Europe (specifically the EEC) and Japan. Recognizing that it will continue to be highly dependent on other parts of the world for wood

TABLE 7-36. IMPORTS AND EXPORTS OF PULP, PAPER, AND PAPERBOARD*

| Product | 1978 ($10^3$ tons) Imports | 1978 ($10^3$ tons) Exports | Percent of Total Imports | Percent of Total Exports |
|---|---|---|---|---|
| Wood Pulp, Total | 4,024 | 2,599 | 30.2% | 47.1% |
| Dissolving | 189 | 757 | 1.4 | 13.7 |
| Sulphite, Total | 484 | 210 | 3.6 | 3.8 |
| Bleached | 417 | 190 | 3.1 | 3.4 |
| Unbleached | 67 | 20 | 0.5 | 0.4 |
| Sulphate, Total | 3,143 | 1,569 | 23.6 | 28.4 |
| Bleached | 2,813 | 1,400 | 21.1 | 25.4 |
| Semi-Bleached | 130 | 93 | 1.0 | 1.7 |
| Unbleached | 200 | 76 | 1.5 | 1.4 |
| Soda, Screening, Other | ** | 62 | ** | 1.1 |
| Other | 207 | | 1.6 | |
| Paper and Paperboard | 9,319 | 2,921 | 69.8 | 52.9 |
| Paper, Total | 8,592 | 543 | 64.4 | 9.8 |
| Newsprint | 7,484 | 82 | 56.1 | 1.5 |
| Uncoated Groundwood | 522 | 58 | 3.9 | 1.1 |
| Coated Printing | 214 | 74 | 1.6 | 1.3 |
| Uncoated Free Sheet | | 85 | | 1.5 |
| Uncoated Printing | 725 | | 5.4 | |
| Thin, Excl. Cigarette | 7 | 27 | 0.1 | 0.5 |
| Writing, Excl. Thin | 12 | | 0.1 | |
| Cotton Fiber | N.A. | 12 | | 0.2 |
| Bristols | 1 | 11 | 0.0 | 0.2 |
| Unbleached Kraft, Total | 65 | 45 | 0.5 | 0.8 |
| Glassine | 5 | 8 | 0.0 | 0.1 |
| Other Packaging | 67 | 36 | 0.5 | 0.7 |
| Special Industrial | 1 | 84 | 0.0 | 1.5 |
| Tissue, Total | 12 | 21 | 0.1 | 0.4 |
| Paperboard, Total | 100 | 2,282 | 0.7 | 41.3 |
| Kraft Linerboard | | 1,605 | | 29.1 |
| Corrugating Medium | | 32 | | 0.6 |
| Bleached Packaging | | 441 | | 8.0 |
| Recycled Paperboard | | 204 | | 3.7 |
| Containerboard | 32 | | 0.2 | |
| Other Paperboard | 68 | | 0.5 | |
| Wet Machine Board | 3 | 8 | 0.0 | 0.1 |
| Construction Paper & Board | 625 | 89 | 4.7 | 1.6 |
| Total Pulp, Paper and Board | 13,343 | 5,520 | | |

*U.S. Bureau of Census, as reported in American Paper Institute, *Statistics of Paper and Paperboard, 1979.*

**Included with Sulphate Pulp Imports.

resources, Japan has entered joint-venture agreements with North American paper companies to build mills in the U.S. and Canada for Newsprint and other relatively low-priced grades. An example is the recent agreement between Oji Paper Company, Mitsui and Company, and International Paper Company to expand Newsprint capacity in New Brunswick.* In the past, Japan has obtained raw materials, principally wood chips, abroad but manufactured paper products at home.

This growing international trade will be concentrated in a few grades, particularly Bleached Kraft Pulp, Newsprint and Unbleached Kraft Linerboard. Two of these are already important export grades for the U.S. Pulp will continue to be important since it is an excellent way of transferring wood resources. Wood prices do not support the high transportation costs associated with trading raw fiber. On the other hand, paper production provides substantial employment and value added, so countries prefer not to import paper.

The most important factor determining a country's ability to compete will be relative production costs. This differential in costs between regions will show up mainly in wood costs. The U.S. continues to benefit from relatively low-cost wood supplies. A second factor in determining export market share is domestic demand relative to capacity. Much of the U.S. expansion of capacity is expected to be used to meet domestic demand.

The major exporting countries are: Scandinavia, Canada, the United States, and Brazil. Scandinavia has relatively high cost wood, but low cost energy and low delivery costs to the EEC. Based on this, plus Scandinavia's production expertise, DRI expects pulp mills to be upgraded for use in paper production. This would result in good growth in Scandinavian paper and board production and exports. For Canada, DRI forecasts continuing growth in pulp exports, with the primary destinations changing to East Asia, Japan and Western Europe. In the case of the United States, much of the new investment will be aimed at satisfying growing domestic needs. Export growth will be concentrated in the Bleached Kraft grades. Brazil has the potential to become a major exporter of pulp, due to its low cost wood and labor. However, DRI does not foresee extensive investment in Brazilian market pulp capacity until the mid-1980's.

Predictions of future import and export levels are available for selected products from DRI. These predictions do not explicitly take account of future cost increases due to pollution control requirements but they do indicate the type of changes which can be expected in these sectors. Table 7-37 summarizes the changes in levels of imports and exports for these product sectors. For each case, the average annual rate of change is given. In some cases, this summary statistic masks large variations from this trend over the period.

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*Paper Trade Journal, September 15, 1980, p. 89.

### TABLE 7-37. FUTURE EXPORT AND IMPORT LEVELS FOR SELECTED PULP, PAPER AND PAPERBOARD SECTORS*

| Product Sector | 1978 ($10^3$ tons) | 1985 ($10^3$ tons) | 1978 as a Percent of 1978 Consumption | Average Annual Rate of Change** |
|---|---|---|---|---|
| Coated Printing | | | | |
| Imports | 215 | 53 | 5.2% | 20.0% |
| Exports | 74 | 124 | 1.8% | 7.4% |
| Uncoated Groundwood | | | | |
| Imports | 608 | 1,081 | 32.7% | 8.2% |
| Exports | 57 | 86 | 3.1% | 5.9% |
| Thin Papers | | | | |
| Imports | 3.4 | 5.2 | 1.8% | 6.1% |
| Exports | 21.9 | 20.0 | 11.7% | -1.3% |
| Newsprint | | | | |
| Imports*** | 7,274 | 6,300 | 61.1% | -2.1% |
| Exports | 161 | 235 | 1.0% | 5.4% |
| Uncoated Freesheet | | | | |
| Imports | 108 | 124 | 3.5% | 2.0% |
| Exports | 85 | 86 | 2.8% | 0.2% |
| Kraft Papers | | | | |
| Imports | 100 | 74 | 2.3% | -4.3% |
| Exports | 57 | 98 | 1.3% | 7.7% |
| Unbleached Kraft Linerboard | | | | |
| Exports | 1,466 | 2,085 | 12.5% | 5.0% |
| Semi-Chemical Corrugating Medium | | | | |
| Exports | 119 | 131 | 2.8% | 1.4% |
| Total Pulp, including Dissolving Pulp | | | | |
| Imports | 3,609 | 4,246 | 7.7% | 2.3% |
| Exports | 2,187 | 2,949 | 4.6% | 4.3% |
| Dissolving Pulp | | | | |
| Imports | 171 | 167 | 24.6% | -0.3% |
| Exports | 753 | 720 | 108.2% | -0.6% |

*Based on Pulp and Paper Review, June 1980, Data Resources, Inc.

**This does not accurately reflect the volatile nature of some product sectors.

***Imports = Consumption - U.S. Domestic Shipments - Inventory Change

Among the paper sectors, imports are extremely important in Uncoated Groundwood and Newsprint, and to a lesser degree in Coated Printing Paper and Uncoated Freesheets. For three sectors, DRI expects exports to increase at a faster rate than imports: Coated Printing, Newsprint, and Kraft Papers. For Thin Papers, exports will continue to far exceed imports even though imports are expected to increase at a faster rate.

Overall, the United States imports considerably more pulp than we export. DRI expects exports to increase at nearly twice the rate of imports. However, this will only reduce our trade imbalance in pulp.

For two paperboard products, Unbleached Kraft Linerboard and Semi-Chemical Corrugating Medium, DRI predicts only exports. In both cases, exports are expected to increase.

Our demand/supply analysis for the paper, paperboard, and Dissolving Pulp product sectors includes projections of future prices if no further controls were imposed and under various levels of pollution control. Table 7-38 below summarizes this information comparing 1983-85 prices with no controls. In most cases the differences in the prices are relatively small. The largest relative price increases are experienced by Newsprint, Bleached Kraft Linerboard, Bleached Kraft Foldingboard, and Dissolving Pulp. Newsprint is already a large import sector with DRI predicting a decrease in imports. This price will probably have little impact on the size of this reduction. Bleached Linerboard is a very small export and import sector. Trade in Bleached Kraft Foldingboard is not significant. Dissolving Pulp does have a large traded share, with exports as large as domestic consumption. Demand is price-sensitive, because Dissolving Pulp competes with products in other industries such as natural and synthetic fibers.

Nothing conclusive can be said about shifts in imports and exports without information on changes in prices in competing countries. Much of our competition comes from Canada and Scandinavia, which are also implementing pollution controls. In 1978 it was predicted that capital expenditures for pollution control by Canadian pulp and paper producers will average about $107 million a year for 1978-1983.* This is well above expenditures for pollution abatement in the past. Part of this cost has been financed by the Canadian national and provincial governments as part of their modernization program. Financing for a Canadian government modernization program started in February 1979 was recently increased from $239 million to $276 million.**

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*Paper Trade Journal, July 15, 1978, p. 50.

**Paper Trade Journal, September 15, 1980, p. 27.

TABLE 7-38 IMPACT OF POLLUTION CONTROLS ON PRICES OF FOREST PRODUCTS*

| Product Sector | 1983-1985 Average Price per Ton, without Controls | 1983-1985 Average Price per Ton, with Proposed Regulation | Ratio of Price with Controls to Price Without |
|---|---|---|---|
| Paper | | | |
| Unbleached Kraft | 294 | 297 | 1.01 |
| Bleached Kraft | 350 | 353 | 1.01 |
| Glassine | 873 | 889 | 1.02 |
| Tissue | 956 | 958 | 1.00 |
| Special Industrial Papers | 945 | 951 | 1.01 |
| Newsprint | 299 | 309 | 1.03 |
| Coated Printing | 600 | 603 | 1.00 |
| Uncoated Freesheet | 580 | 585 | 1.01 |
| Uncoated Groundwood | 485 | 485 | 1.00 |
| Thin Papers | 672 | 673 | 1.00 |
| Solid Bleached Bristols | 488 | 491 | 1.01 |
| Cotton Fibre | 1,480 | 1481 | 1.00 |
| Paperboard | | | |
| Unbleached Linerboard | 230 | 234 | 1.02 |
| Bleached Linerboard | 267 | 274 | 1.03 |
| Bleached Foldingboard | 438 | 454 | 1.04 |
| Solid Bleached Board | 464 | 467 | 1.01 |
| Semi-Chemical Corrugating Medium | 220 | 226 | 1.02 |
| Recycled Linerboard | 202 | 202 | 1.00 |
| Recycled Corrugating Medium | 211 | 214 | 1.01 |
| Recycled Foldingboard | 358 | 358 | 1.00 |
| Construction Paper & Board | 269 | 269 | 1.00 |
| Pulp | | | |
| Dissolving | 364 | 374 | 1.03 |

*Based on Table 7-3 and Table 7-16.

According to the Swedish Pulp and Paper Association,* Swedish pulp and paper companies have invested about $380 million in pollution controls over the last decade. This has resulted in cutting mill pollution in half, despite increases in production. They estimate that $313 million will be invested by the mid-1980's in pollution control. Some 55-60 percent is earmarked for water conservation, 25-30 percent for water purification, 12-14 percent for air conservation, and 6-7 percent for research and development.

Another factor affecting the United States' competitive position is changes in exchange rates among major currencies. The strengthening of the Japanese yen against the U.S. dollar has helped U.S. exports to Japan, just as the weakness of the Canadian dollar against the U.S. dollar has helped Canada's exports. Again, it is difficult to predict changes in relative exchange rates.

To summarize, for most product sectors, and all the important U.S. export sectors, the price increases resulting from the Proposed Regulation pollution controls are relatively small. In addition, we can expect to continue to benefit from relatively low cost wood. Canadian mills are benefiting from a government grant program to help finance their modernization and pollution control programs, and Scandinavia is benefiting from the elimination of tariffs with the EEC. These, plus changes in exchange rates, are likely to have a greater impact on the U.S. competitive position than price increases due to the proposed pollution controls.

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*Paper Trade Journal, May 15, 1979, p. 62.

## Appendix 7-A

### Projected Annual Capacity Levels, by Sector ($10^3$ short tons)

| Sector | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | Average Percent Growth Rate |
|---|---|---|---|---|---|---|---|---|
| Pulp | | | | | | | | |
| Dissolving Pulp | 1,536 | 1,537 | 1,537 | 1,537 | 1,537 | 1,537 | 1,537 | 0 |
| Paper | | | | | | | | |
| Unbleached Kraft | 4,261 | 4,286 | 4,238 | 4,303 | 4,470 | 4,550 | 4,620 | 1.3% |
| Bleached Kraft | 1,051 | 1,052 | 1,071 | 1,079 | 1,090 | 1,101 | 1,112 | 0.9% |
| Glassine | 220 | 222 | 224 | 227 | 229 | 231 | 233 | 1.0% |
| Tissue | 4,885 | 5,085 | 5,195 | 5,395 | 5,447 | 5,458 | 5,474 | 1.9% |
| Special Industrial | 928 | 945 | 959 | 970 | 989 | 1,009 | 1,029 | 1.7% |
| Newsprint | 4,109 | 4,545 | 5,119 | 5,433 | 5,829 | 6,165 | 6,416 | 7.4% |
| Coated Printing | 4,741 | 5,017 | 5,366 | 5,511 | 5,649 | 6,022 | 6,348 | 4.9% |
| Uncoated Freesheet | 8,095 | 8,532 | 8,742 | 8,851 | 9,000 | 9,337 | 9,901 | 3.4% |
| Uncoated Groundwood | 1,537 | 1,532 | 1,532 | 1,555 | 1,793 | 1,904 | 2,022 | 4.6% |
| Thin Papers | 412 | 422 | 404 | 434 | 441 | 453 | 465 | 2.0% |

## Appendix 7-A (continued)

### Projected Annual Capacity Levels, by Sector ($10^3$ short tons)

| Sector | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | Average Percent Growth Rate |
|---|---|---|---|---|---|---|---|---|
| Solid Bleached Bristols | 1,146 | 1,133 | 1,115 | 1,118 | 1,125 | 1,136 | 1,148 | 0 |
| Cotton Fiber | 129 | 129 | 129 | 129 | 131 | 131 | 131 | 0.3% |
| **Paperboard** | | | | | | | | |
| Unbleached Linerboard | 14,087 | 14,480 | 15,066 | 15,638 | 16,058 | 16,774 | 17,587 | 3.7% |
| Bleached Linerboard | 133 | 135 | 138 | 139 | 142 | 147 | 152 | 2.2% |
| Bleached Foldingboard | 2,080 | 2,150 | 2,199 | 2,219 | 2,235 | 2,268 | 2,320 | 1.8% |
| Solid Bleached Milk & Other | 2,105 | 2,110 | 2,120 | 2,136 | 2,157 | 2,179 | 2,201 | 0.7% |
| Semi-Chemical Corrugating | 4,851 | 4,879 | 4,965 | 5,263 | 5,517 | 5,707 | 5,899 | 3.3% |
| Recycled Foldingboard | 3,009 | 3,053 | 3,117 | 3,127 | 3,136 | 3,150 | 3,178 | 0.9% |
| Recycled Linerboard | 354 | 357 | 380 | 413 | 414 | 421 | 433 | 3.4% |
| Recycled Corrugating | 1,700 | 1,802 | 1,829 | 1,849 | 1,897 | 1,946 | 1,997 | 2.7% |

## Appendix 7-A (continued)

| Sector | Projected Annual Capacity Levels, by Sector ($10^3$ short tons) | | | | | | | Average Percent Growth Rate |
|---|---|---|---|---|---|---|---|---|
| | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | |
| Construction Paper & Board | 7,067 | 7,138 | 7,209 | 7,281 | 7,354 | 7,427 | 7,501 | 1.0% |
| All Other Paperboard including Unbleached Foldingboard | 5,055 | 5,147 | 5,192 | 5,207 | 5,303 | 5,377 | 5,443 | 1.2% |

## APPENDIX 7-B

## FORECASTS OF DEMAND INDICATORS

| Product Sector | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | Avg. Percent Increase |
|---|---|---|---|---|---|---|---|---|
| PAPER | | | | | | | | |
| Unbleached Kraft | | | | | | | | |
| UPPTOTENDUSE | 1.43 | 1.44 | 1.46 | 1.54 | 1.60 | 1.64 | 1.69 | 2.8 |
| Bleached Kraft | | | | | | | | |
| BPPTOTENDUSE | 1.49 | 1.51 | 1.53 | 1.61 | 1.68 | 1.73 | 1.81 | 3.3 |
| Glassine and Greaseproof, Special Industrial, Uncoated Freesheet, Thin Papers, Solid Bl. Bristols, Cotton Fibre | | | | | | | | |
| GNP72 | 1432 | 1434 | 1455 | 1518 | 1569 | 1611 | 1673 | 2.6 |
| Newsprint | | | | | | | | |
| JCIRNPA@US | 106 | 106 | 106 | 107 | 107 | 108 | 109 | 0.5 |
| Coated Printing | | | | | | | | |
| JQINDCPRT14 | 1.52 | 1.52 | 1.54 | 1.61 | 1.66 | 1.71 | 1.77 | 2.6 |
| ADVPAG@MAG | 29.9 | 30.0 | 30.9 | 32.9 | 34.8 | 36.1 | 37.6 | 3.9 |
| JQINDOSI | 1.51 | 1.53 | 1.56 | 1.64 | 1.70 | 1.75 | 1.82 | 3.2 |
| Uncoated Groundwood | | | | | | | | |
| JQIND27ENW | 1.45 | 1.46 | 1.53 | 1.59 | 1.66 | 1.73 | 1.81 | 3.8 |
| Tissues | | | | | | | | |
| HH | 78.4 | 79.8 | 81.8 | 83.5 | 85.1 | 86.6 | 88.2 | 2.0 |

## APPENDIX 7-B

## FORECASTS OF DEMAND INDICATORS (continued)

| Product Sector | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | Avg. Percent Increase |
|---|---|---|---|---|---|---|---|---|
| PAPERBOARD | | | | | | | | |
| Unbleached Linerboard, Bl. Linerboard, Rec. Linerboard, Semi-Chem. Corrugating, Recycled Corrugating (Fibre Box end-uses) | | | | | | | | |
| JQINDGR1 | 1.33 | 1.36 | 1.38 | 1.42 | 1.47 | 1.49 | 1.53 | 2.4 |
| JQINDGR2 | 1.80 | 1.85 | 1.91 | 2.01 | 2.11 | 2.19 | 2.27 | 3.9 |
| JQINDGR3CDUR | 1.62 | 1.59 | 1.73 | 1.93 | 1.99 | 2.03 | 2.12 | 4.6 |
| JQINDGR3NDUR | 1.27 | 1.24 | 1.25 | 1.32 | 1.36 | 1.39 | 1.43 | 2.0 |
| JQINDGR3PDUR | 1.53 | 1.46 | 1.47 | 1.58 | 1.65 | 1.68 | 1.77 | 2.5 |
| JQINDGR4CDUR | 1.54 | 1.52 | 1.57 | 1.68 | 1.78 | 1.83 | 1.93 | 3.8 |
| JQIND22 | 1.44 | 1.39 | 1.44 | 1.59 | 1.68 | 1.71 | 1.80 | 3.8 |
| JQINDGR4PDUR | 2.76 | 2.71 | 2.81 | 3.19 | 3.48 | 3.64 | 3.98 | 6.3 |
| JQINDGR5NDUR | 1.63 | 1.63 | 1.67 | 1.79 | 1.87 | 1.92 | 2.03 | 3.7 |
| JQINDGR5PDUR | 1.64 | 1.49 | 1.63 | 1.85 | 1.89 | 1.92 | 2.09 | 4.1 |
| FIBSHPGR6 | 14.7 | 14.8 | 14.8 | 14.9 | 15.0 | 15.1 | 15.1 | 0.5 |
| Bl. Foldingboard, Rec. Foldingboard, Setup Boxboard | | | | | | | | |
| CNBOX72 | 317 | 323 | 325 | 334 | 343 | 351 | 360 | 2.1 |
| CN72 | 344 | 345 | 356 | 365 | 374 | 385 | 398 | 2.5 |
| Construction Paper and Board | | | | | | | | |
| ICR72 | 55.2 | 45.0 | 49.3 | 58.8 | 60.1 | 61.1 | 66.4 | 3.1 |
| Solid Bleached Bd. | | | | | | | | |
| CNFOOD72 | 169 | 173 | 173 | 177 | 181 | 183 | 185 | 1.5 |

## APPENDIX 7-B

## FORECASTS OF DEMAND INDICATORS (continued)

| Product Sector | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | Avg. Percent Increase |
|---|---|---|---|---|---|---|---|---|
| PAPERBOARD | | | | | | | | |
| All Other Board | | | | | | | | |
| JQIND | 1.51 | 1.48 | 1.56 | 1.62 | 1.69 | 1.82 | 1.93 | 4.2 |
| ICR72 | 53.2 | 45.0 | 49.3 | 58.8 | 60.1 | 61.1 | 66.4 | 3.1 |
| JQINDUKB | 1.79 | 1.84 | 1.88 | 1.99 | 2.08 | 2.16 | 2.24 | 3.8 |
| PULP | | | | | | | | |
| Dissolving | | | | | | | | |
| JQINDDIS | 1.50 | 1.37 | 1.42 | 1.54 | 1.61 | 1.67 | 1.72 | 2.3 |

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Source: DRI macroeconomic forecast, March, 1980.

Notes: Variable names are defined in Appendix 2-B

# Section 8

# Limits of the Analysis

This section discusses the major limitations of the assumptions, methodology and results of the analysis. It also presents the results of a number of sensitivity analyses which test the robustness of the results of Section 7. It is organized into parts which parallel those of the methodology and results sections (2 and 7 respectively), i.e., costs of compliance and construction of supply curves, demand/supply analysis, capital availability, mill closures, community impacts,and balance of trade effects.

The part on costs and supply curves discusses the effect of real cost increases between 1978 and 1983-85 and the problems of aggregating production cost data for different grades within a product sector. The sensitivity of pollution costs to the value of the capital recovery factor and the mix of new and existing sources is examined. In general, cost and price increases are underestimated somewhat if real cost increases are not included. The effect of this on the results of the capital availability and closure analyses is not clear, however.

The discussion of the demand/supply analysis includes the implications of assuming competitive markets, the consistency of the results with long-run equilibrium, and problems of aggregation. The sensitivity of the results to alternative prices of substitute goods and alternative macroeconomic forecasts is examined.

Issues in the capital availability analysis include the reliability of capacity expansion costs and revenue estimates.

The part on the closure analysis focuses on the limitations of 308 Survey data, the reliance on a straight present value calculation, and the assumptions about real cost increases. The sensitivity of the results to the definition of salvage value, the treatment of transfer mills (i.e. those mills integrated forward to converting operations), and the price forecasts is examined. In general, the estimates of base closures show substantial variation, but those of added closures due to treatment costs are quite stable.

## Costs of Compliance, Supply Curve Construction

### Estimation of Production Costs

The supply curves are constructed from estimates of mills' variable production costs and total annual costs of pollution control. Variable costs are taken from the 308 Survey and pollution control costs from the technical contractor's estimates. This section describes some of the limitations of these cost estimates and the methodology for constructing the product sector supply curves. It also describes the results of varying the cost of capital and the mix of new and existing sources on estimates of costs of compliance.

The most significant limitation in using variable production costs from the 308 Survey is that they are not adjusted to take into account increases in the real costs of inputs such as energy, chemicals, labor and wood and/or pulp. For example, DRI forecasts the following percent increases in real costs between 1978 and 1985:*

| | | |
|---|---|---|
| Unit labor | 3.5% | |
| Chemicals | 18.0% | |
| Fuel and light | 148.4% | |
| Pulp | 22.7% | (1979-1985) |
| Softwood Pulpwood | 8.4% | |
| Hemlock Wood Chips | 29.0% | |

However, inflating reported costs by these amounts would overestimate actual increases since mills will alter their production processes somewhat in response to higher costs. For example, chips and other scraps, which had previously been discarded, are being used increasingly as an energy source.

Nevertheless, real costs probably will increase about 5-15% over the period depending on the particular product sector.** This implies that because the demand/supply analysis assumes constant costs, 1983-85 base case prices will be underestimated and output overestimated. This is likely to have little effect on the analysis of price increases due to BCT pollution regulations because such increases depend on the elasticities of supply and demand. Although the level of variable costs will be underestimated, the curvature of the supply curve, and hence the elasticity of output with respect to price changes, should not be much affected.

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*Source: DRI estimates, June 1980 forecast.

**See DRI Pulp and Paper Review, June 80.

The effect of underestimating production costs on the capital availability and closure analyses is not definite either. For each product sector, prices and unit variable costs would be lower and output higher than otherwise. Therefore the bias on total revenues and total variable costs will be smaller, so the estimates of cash flow available for investment should be fairly stable. Similarly, since output for individual mills in the closure analysis is assumed fixed, both revenues and costs will be underestimated, so the net effect of this on the closure results is unclear.

There are certain inherent difficulties in using survey data. These are also discussed in Appendix 2-A. Some problems arise due to ambiguities in the definitions of various cost items. For example, it was not clear whether the item "other variable costs" included current pollution control costs and freight costs, so not all respondents may have answered the question consistently. Nevertheless, these estimates are probably as good as can be obtained.

### Estimation of Treatment Costs

Pollution control costs were obtained from the technical contractor. As described in Section 6, treatment requirements of the Proposed Regulation are defined for some mills on an individual or "exemplary mill" basis and for other mills as the installation of a specific level of treatment technology. In either case, costs were ultimately developed from "model" mills and hence will only approximate actual costs borne by individual mills. However, they should provide reasonable estimates of overall compliance costs in a given subcategory or product sector.

In calculating total annual costs, a single cost of capital was used for all mills. Although this estimate was based on industry-wide data, use of a single value may bias the shape of the supply curve when total annual pollution control costs are added to variable production costs. (See Section 2.) For example, if mills with lower variable costs tend to be larger and owned by larger companies with lower costs of capital, using a single cost of capital will make the post-regulation supply curve flatter than it should be. However, total annual costs are not overly sensitive to variations in the cost of capital. Table 8-1 shows average total annual costs per ton for direct dischargers in each subcategory under the Proposed Regulation. Total annual costs are shown for three values of the capital recovery factor: 0.17, 0.22 (the base assumption), and 0.27. In most cases the alternative values fall within a bracket of ±15 percent of the base value.

### TABLE 8-1. Effect of Capital Recovery Factor on Total Annual Costs: Proposed Regulation

| | Average Total Annual Costs ($/ton) | | |
|---|---|---|---|
| | ---------- Value of CRF --------- | | |
| | 17% | 22% | 27% |
| **Integrated** | | | |
| Dissolving Kraft | * | * | * |
| Market Bl. Kraft | 7.8 | 9.2 | 10.6 |
| BCT Bl. Kraft | 6.8 | 8.2 | 9.6 |
| Fine Bl. Kraft & Soda | 7.3 | 8.7 | 10.1 |
| Unbl. Kraft (Linerboard) | 2.6 | 3.1 | 3.6 |
| Unbl. Kraft (Bag) | 5.0 | 5.8 | 6.6 |
| Semi-Chemical | 3.2 | 3.7 | 4.2 |
| Unbl. Kraft and Semi-Chem. | 3.3 | 4.0 | 4.7 |
| Dissolving Sulfite Pulp | 0 | 0 | 0 |
| Papergrade Sulfite | 12.7 | 15.0 | 17.3 |
| Groundwood Thermo-Mechanical | * | * | * |
| Groundwood Coarse, Molded, Newspaper | * | * | * |
| Groundwood -- Fine Papers | 4.8 | 5.9 | 7.0 |
| Misc. Integrated Mills | 4.8 | 5.8 | 6.8 |
| **Secondary Fiber** | | | |
| Deink (Fine Papers) | * | * | * |
| Deink (Newsprint) | 0 | 0 | 0 |
| Deink (Tissue) | 12.6 | 14.6 | 16.6 |
| Tissue from Wastepaper | 12.7 | 14.5 | 16.3 |
| Paperboard from Wastepaper | 2.6 | 2.9 | 3.2 |
| Wastepaper Molded Products | * | * | * |
| Builders Paper & Roofing Felt | 0 | 0 | 0 |
| Misc. Secondary Fiber Mills | 3.3 | 3.8 | 4.3 |
| **Nonintegrated** | | | |
| Nonintegrated Fine Papers | 4.5 | 5.3 | 6.1 |
| Nonintegrated Tissue Papers | 0.7 | 0.9 | 1.1 |
| Nonintegrated Lightweight | 3.4 | 4.3 | 5.2 |
| Nonintegrated Filter & Non-woven | 0 | 0 | 0 |
| Nonintegrated Lightweight -- Electrical Allowance | 0 | 0 | 0 |
| Nonintegrated Paperboard | 0 | 0 | 0 |
| Misc. Nonintegrated Mills | 4.2 | 5.3 | 6.4 |

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Source: Meta Systems estimates

*Suppressed due to confidentiality.

Like variable production costs, variable pollution control costs are not escalated from real 1978 levels. Therefore total annual pollution costs are underestimated. Price impacts would be underestimated by a similar magnitude. Again, the bias of the underestimations in the capital availability and closure analyses is less clear because both price and cost rises are underestimated.

Finally, pollution control costs of new mills may be overestimated if they are able to reduce costs by making changes in design or production process prior to construction. These possibilities could not be included in the analysis. However it is quite reasonable to make the conservative assumption of excluding them.

### Total Costs of Compliance

The data from the 308 Survey give a detailed picture of the industry in 1978. In order to predict costs of compliance in 1983, it is necessary to forecast the increase in capacity in each subcategory and the fraction of that capacity which will be classified as new capacity and hence subject to NSPS requirements. Given the forecast of capacity expansion in each product sector, a forecast for expansion by subcategory was developed based on the present mix of subcategories in each sector and the belief that most expansion would take place in integrated mills. This makes the estimates of the costs of compliance high relative to most mother mixes of integrated and nonintegrated mills that might be considered.

The mix of new and existing sources is a more diffcult problem. As was discussed in Section 7, costs for meeting NSPS standards are substantially higher than the average costs for existing sources because they include BPT costs as well. Using them will overestimate costs if the capacity expansion costs taken from the 308 Survey already include some treatment costs. The mix of new sources used in Section 7 was based on announced plans of existing mills. Table 8-2 shows what total costs of compliance for the Proposed Regulation would be if all capacity coming onstream after 1982 was classified as new sources. Total capital costs are $1445.7 million and total annual costs are $464.6 million (6.3 and 8.0 percent greater, respectively, than the base forecasts).

### Supply Curve Construction

The construction of the product sector supply curves from the individual mill data also has a number of limitations. Perhaps the most fundamental one is the implicit assumption that all production within a product sector is homogeneous and hence that mills can be ranked on the basis of unit variable costs. This is quite plausible for relatively standardized grades such as linerboard or Newsprint, but less so for

TABLE 8-2. Total Costs of Compliance When All New Capacity In Place After 1981 is Subject to NSPS Costs: Proposed Regulation

| | Millions of Dollars (1978) | | | |
|---|---|---|---|---|
| | Capital Costs | | Total Annual Costs | |
| | Existing | New | Existing | New |
| Integrated | | | | |
| Dissolving Kraft | * | 0 | * | 0 |
| Market Bl. Kraft | 66.2 | 8.9 | 21.0 | 3.0 |
| BCT Bl. Kraft | 82.0 | 18.2 | 24.3 | 6.2 |
| Fine Bl. Kraft & Soda | 149.2 | 46.1 | 46.0 | 16.4 |
| Unbl. Kraft (Linerboard) | 66.3 | 34.9 | 20.2 | 11.4 |
| Unbl. Kraft (Bag) | 43.7 | 5.6 | 13.1 | 1.8 |
| Semi-Chemical | 33.4 | 18.8 | 11.3 | 6.3 |
| Unbl. Kraft and Semi-Chem. | 72.0 | 26.2 | 21.1 | 8.9 |
| Dissolving Sulfite Pulp | 0 | 0 | 0 | 0 |
| Papergrade Sulfite | 90.2 | 23.8 | 28.3 | 8.0 |
| Groundwood Thermo-Mechanical | * | * | * | * |
| Groundwood Coarse, Molded, Newspaper | * | * | * | * |
| Groundwood -- Fine Papers | 24.4 | 21.9 | 8.4 | 7.3 |
| Misc. Integrated Mills | 395.5 | 58.3 | 121.1 | 24.3 |
| Secondary Fiber | | | | |
| Deink (Fine Papers) | * | 0 | * | 0 |
| Deink (Newsprint) | 0 | 5.2 | 0 | 2.2 |
| Deink (Tissue) | 21.2 | 3.0 | 7.8 | 1.3 |
| Tissue from Wastepaper | 3.6 | 0 | 1.4 | 0 |
| Paperboard from Wastepaper | 15.9 | 8.2 | 7.7 | 3.0 |
| Wastepaper Molded Products | * | 0 | * | 0 |
| Builders Paper & Roofing Felt | 0 | 4.7 | 0 | 1.9 |
| Misc. Secondary Fiber Mills | 7.8 | 5.7 | 2.7 | 3.4 |
| Nonintegrated | | | | |
| Nonintegrated Fine Papers | 12.7 | 0.9 | 3.9 | 0.3 |
| Nonintegrated Tissue Papers | 1.7 | 0 | 0.4 | 0 |
| Nonintegrated Lightweight | 4.7 | 3.3 | 1.1 | 1.4 |
| Nonintegrated Filter & Non-woven | 0 | 0 | 0 | 0 |
| Nonintegrated Lightweight -- Electrical Allowance | 0 | 0 | 0 | 0 |
| Nonintegrated Paperboard | 0 | 0 | 0 | 0 |
| Misc. Nonintegrated Mills | 10.1 | 0 | 2.3 | 0 |
| Total | 1145.8 | 299.9 | 355.5 | 109.1 |

Source: Meta Systems estimates

*Suppressed due to confidentiality.

Tissues or Special Industrial Papers. If this assumption does not hold reasonably well, it raises two major problems. First, the elasticity of supply implied by the curvature of the constructed supply curve may be incorrect since mills in the same market (i.e. producing the same quality grade) may not be grouped together in the supply curve.

Secondly, if there is no single grade price, it is not clear which region of the supply curve contains the marginal mills whose costs determine price. If unit cost increases due to treatment costs vary significantly in different regions of the supply curve, there is no basis for choosing which cost increases determine the resulting price increase.

In other words, both the supply elasticity and the amount of the cost increase on which the price increase is based may be either over- or underestimated.* This situation may occur in several product sectors which have a significant range of grade qualities, unit variable production costs, and unit total annual treatment costs. These include Special Industrial Papers, Thin Papers, Cotton Fibre, Tissues, and All Other Board.

The construction of the supply curve using average variable costs is an approximation, because marginal variable costs should vary with output. Nevertheless, variable costs are probably fairly constant over a wide range of output. In any case, the survey data only allow a point estimate of unit variable costs. The step function structure of the supply curve resulting from the use of average costs implies that all mills with average variable costs less than price operate at full capacity while those with higher costs do not operate at all. This is of course not realistic. However, the supply curve so constructed is useful if it approximates the overall elasticity of supply in the product sectors and reflects the effect of changes in demand on capacity utilization. High-cost mills in a homogeneous product sector have greater fluctuations in output than do low-cost mills. Therefore ranking them on the basis of unit cost should give some idea of the price-responsiveness of output.

A couple of other simplifications of the supply curve construction should be mentioned. If a mill has production in more than one product sector, treatment costs are allocated to each sector on an equal per ton basis. If mills actually allocate cost on the basis of, say, an equal percent price rise, this will introduce some small distortion. Also, possibilities for switching a machine from producing one grade to producing another are not taken into account. However, it is unlikely that mills would alter their product mix because of treatment requirements.

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*The question of whether or not price is determined by the marginal mill, i.e. if the market is competitive, is taken up in the following section on the demand/supply analysis.

## Demand/Supply Analysis

The demand/supply methodology is the core of the analysis. It provides base forecasts of price, output and contribution to capital and forecasts of the impacts of pollution control costs on these variables. These are used as inputs to the capital availability, closure, community impact and balance of trade analyses.

The demand/supply model can be characterized as a competitive short-run model where the market for each product grade is cleared in each period by setting price equal to marginal variable costs (including total annual treatment costs). The methodology raises several important questions. Is it reasonable to assume that markets are competitive, and if not, what are the probable biases of doing so? Are the short-run equilibria consistent with longer-run equilibrium expectations about the profitability of new investments in the industry? What are the problems of aggregating over different grades within a specific product sector? Each of these questions is discussed in this part. The limitations of the lack of a demand/supply model for Market Pulp, Molded Pulp and All Other Paper are also explored.

The market structure of the pulp and paper industry was discussed in Section 5. To briefly review, the pulp and paper industry has a number of characteristics which suggest that markets are not completely competitive. Several product such as Dissolving Pulp, Glassine and Greaseproof, Unbleached Kraft and Foldingboard have only a few mills. Others such as Special Industrial Papers and Coated Printing have a larger number of mills overall but contain a number of distinct grades. Other product sectors are dominated by a few large mills. All these factors must confer some market power on some of the larger producers. Of course, some further competitive discipline is imposed by possibilities of substitution among product sectors on both the demand and supply sides. Also, increases in profitability tend to be responded to with significant increases in capacity, suggesting that it is difficult to maintain price above a competitive level.

The problem of how to describe imperfectly competitive markets has vexed economic theory for a long time. As will be discussed below, it is not possible to predict the outcome of price and output in an oligopolistic market. Therefore no single "noncompetitive" model could be used to forecast impacts of treatment requirements on price and output. Instead, the approach taken here is to use the competitive model, but also to examine the limitations and possible biases of doing so.

The basic difficulty of analyzing noncompetitive markets is that except for a few special cases, such as monopoly or price leadership, there is no determinate price and output, and hence no determinate change in those variables from a change in costs due to pollution control requirements. This is because firms in an oligopolistic market must take into account the effects of their actions on other firms. However, no one pattern of behavior will maximize profits independent of the actions of other firms.

In the case of pure monopoly one would expect price to rise by less than in a competitive market in response to a given cost increase. This is because the monopolist equates marginal revenue and marginal cost and the marginal revenue curve has a steeper slope than the demand curve. However, there are no examples of pure monopoly in the pulp and paper industry. In an oligopolistic market where firms strive to maintain market share, the imposition of pollution control costs might serve as a signal which allows all of them to raise prices without disrupting the market. However, this result is not certain.

One way to approach the problem of the effect of treatment costs on price in imperfectly competitive markets is to ask: which mill's cost increase determines the price increase? In a competitive market it is the mill with highest post-treatment variable costs (including annualized capital costs of treatment) which finds it more profitable to invest in pollution control and stay open rather than shut down. In an oligopolistic market, the determining mill could be a large modern mill with lower variable costs which can exert market power to raise prices. If both kinds of mills have similar unit pollution control costs per ton, a competitive and noncompetitive model should yield similar results. If the high cost mill has lower unit compliance costs than the low cost mill, the price increase implied by the competitive model will be less than that of a noncompetitive model, and vice versa if it has higher costs.

If mills with low variable costs tend to be large and have some market power, the range of variable costs in each product sector (see Table 7-5) should give some indication of the extent to which the competitive model mis-estimates price impacts. In Newsprint, one sector which shows evidence of price leadership, unit treatment costs are fairly constant across producers. This suggests that the predicted price increase is fairly robust. In the bleached paper and board sectors, low variable cost mills tend to have higher unit treatment costs. In Tissues, low cost producers have significantly higher treatment costs, but it is hard to judge the effect of this because of the many different grades included in this sector.

In summary, in the absence of a specific model of noncompetitive behavior, the bias of assuming perfect competition is uncertain. It may be more relevant to examine the range of cost increases within a product sector to capture the range of possible price outcomes.

A second question is whether the short-run market equilibria determined by the demand/supply analysis are consistent with the requirement of long-run equilibrium that new capacity in each sector earn a competitive return on capital. The present value of investments in each product sector is examined in the capital availability analysis. The limitations of that analysis are discussed in a subsequent part of this section. In any case, the forecasts of demand growth and capacity expansion used in the demand/supply model should be consistent because both are derived from a consistent forecast by DRI. Demand growth is based on the DRI macro-economic forecast. Capacity forecasts are based on API reports of announced expansions and extended to later years by DRI with a model which predicts investment based on the strength of forecasted demand in each sector.

The capacity expansion forecasts are exogeneous to the demand/supply analysis and do not take into account the loss in profits due to BCT costs. Therefore the analysis of the post-controls case somewhat overestimates capacity and output and underestimates price. However, although overestimating capacity underestimates the price increase, this is partially compensated for because the elasticity of supply is usually greater at a lower level of capacity utilization. In any case, this effect on price impacts will be small.

Overestimating capacity will overestimate the difficulties for the industry of financing new investments for two reasons. First, prices, and hence profits are underestimated. Second, because capacity is overestimated, so is the amount of investment required for pollution control. In general, however, BCT control costs should not have a significant effect on planned investment in capacity.

The problem of aggregation was touched on in the discussion of the supply curves. The use of a single price series to estimate an elasticity of demand does not create major problems. Within each product sector there should be a fairly stable structure which relates the prices of different grades. Therefore the movement of the sample price series should reflect the movements in all similar grades. As was mentioned before, the main problem is with the supply curve. Both the elasticity of the supply curve and the location of the marginal mill on the supply curve may be significantly mis-estimated. This is particularly the case for product sectors with a diversity of grades, such as Special Industrial Papers, Coated Printing, Thin Papers, Tissue, and All Other Board. Although this problem must be considered, the direction or magnitude of any bias in the methodology used is not clear.

Another significant limitation is the lack of a demand/supply analysis for Market Pulp (except Dissolving Pulp). A complete analysis of the Market Pulp sector would be quite difficult. Each of the major pulp types has many different end uses with different demand prospects. Because many pulp types are close substitutes, an equilibrium solution would require information about the substitution possibilities for each pulp type, and the joint determination of demand in a number of product sectors in addition to Market Pulp.

Due to the lack of a demand/supply analysis, no price rises for Market Pulp are forecast. This introduces a significant bias into the analysis by overestimating the impacts on integrated mills. Revenues for integrated mills are underestimated in two ways. First, revenues from sales of Market Pulp do not increase. Second, price increases for paper and board grades will reflect the cost increases of nonintegrated mills, because they tend to have higher variable production costs. Since these cost increases do not include post-control cost increases for Market Pulp, the resulting price increases, and hence the revenue increases from sales of paper and board products, will be underestimated. The net impact of this omission on nonintegrated mills is less clear, since both revenues and costs are underestimated. However, if price increases are higher than predicted, decreases in overall output will be greater than predicted as well. Therefore this omission will have the effect of underestimating shutdowns in the closure analysis. This is because output in the analysis is taken as equal to the value reported in the 308 Survey.

As was mentioned in the part on supply curves, the possibility of a mill switching its output from one product sector to another is not considered. Such switching would significantly affect the results of the demand/supply analysis only if it were likely to occur in a large fraction of total capacity of a given sector. Since the capacity forecasts used for the base case already reflect projected demand growth in each sector, all base case switching has implicitly been accounted for. Switching because of the Proposed Regulation is probably not a major problem, since the regulations are made on the basis of processes rather than product sectors.

The demand/supply analysis was not done for an alternative, more pessimistic macro-economic forecast of the economy. Such an alternative forecast would have no major effect on the analysis of the incremental effects of the regulations, either on prices, capital availability, or mill closures. However, a weaker financial picture of the industry in the base case might make the forecast of, for example, total capital requirements less acceptable.

A number of paper and board sectors have demand equations which include price terms for substitute goods. The substitute good is either another paper product or plastic. (See Table 2-2). In the analysis in Section 7, forecasts of price and other impacts in specific sectors were made using DRI's base case forecast of the price series of the substitute good. However, in most cases the price of the substitute good will also rise because of BCT costs. If the prices of both the own and substitute good rise, the effect of the own good's price on demand will be less than otherwise. Therefore the analysis of Section 7 may underestimate price impacts and overestimate output impacts.

To test the importance of this effect, alternative forecasts of price and other impacts were made using the post-BCT price series for the substitute good under the Proposed Regulation. The results are presented in Table 8-3 for those sectors which have significant cross-price elasticities and whose substitute goods have significant BCT price impacts. The table compares the percent increase in price due to BCT costs in that sector when the substitute good also faces BCT costs with the forecast given in Section 7, Table 7-16. When the substitute was plastics, estimates of BAT/BCT price increases had to be obtained from outside sources. Because more refined data were not available, a price increase of five percent was used.*

Table 8-3 shows that for product sectors where the substitute good is another paper product, only the impact for Uncoated Groundwood is appreciably affected. For those sectors where plastic is the substitute, Glassine and Greaseproof, Bleached Kraft Paper, and Unbleached and Recycled Linerboard and Foldingboard, the impacts on price and output resulting from using the BCT-adjusted substitute prices are different from those obtained using unadjusted substitute prices. However, in no case does the change in assumption qualitatively affect the magnitude of the impact. Moreover, it should be noted that the BAT/BCT regulations for plastics may be promulgated later than those for pulp and paper.

In summary, a number of limitations of the demand/supply analysis have been considered. Price impacts are probably underestimated because (a) real costs were not increased between 1978 and 1983-85; (b) capacity expansion estimates were not adjusted because of added pollution control costs; (c) substitute prices may have been underestimated; and (d) cost impacts on nonintegrated mills did not take increases in pulp costs into account. Only the first and last points are likely to be significant. The effects on the price estimates of (a) assuming competitive markets and (b) aggregation bias are unclear.

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*Source: EPA estimate.

TABLE 8-3. Effect on Demand/Supply Analysis of Using Prices of Substitute Goods Adjusted for BAT/BCT Costs: Proposed Regulation

| | Alternative Estimate of Percent Change from Base Case | | Base Forecast in Section 7* | |
|---|---|---|---|---|
| Product Sector | Price | Output | Price | Output |
| Bl. Kraft Papers | 1.22 | -1.76 | .83 | -2.26 |
| Glassine & Greaseproof | 3.56 | -2.65 | 1.83 | -5.94 |
| Uncoated Groundwood | 1.76 | .65 | 0 | 0 |
| Unbl. Kr. Linerboard | 2.06 | - .76 | 1.86 | - .94 |
| Bl. Kr. Linerboard | 2.73 | - .78 | 2.63 | - .99 |
| Semi-Chem. Corrugating | 2.71 | .27 | 2.48 | -1.76 |
| Rec. Linerboard | 1.26 | 1.79 | .18 | .01 |
| Rec. Foldingboard | 2.40 | 1.30 | .07 | - .08 |
| Rec. Corrugating | 1.70 | 2.15 | 1.41 | 1.90 |
| Solid Bl. Board | .94 | - .53 | .72 | - .64 |

Source: Meta Systems estimates

Note: In some cases (e.g., Uncoated Groundwood) both price and output increase. This is because the substitution effect of the price increase of the substitute outweighs the effect of the good's own price increase.

*See Table 7-16.

## Capital Availability Analysis

The capital availability analysis examines both the effects of BCT costs on the present value of a ton of new capacity and on the total capital requirements in each product sector. Both analyses require a number of assumptions to be made, and changes in these assumptions could have significant effects on the results.

The present value analysis requires three main inputs: base costs of new capacity; treatment costs for new capacity; and a price forecast. Costs of new capacity were taken from reports of planned expenditures in the 308 Survey. In most cases these reports showed a wide variation of dollar per ton costs, and the averages were based on a small number of observations. It was not possible to distinguish between additions of new machines and modifications of existing equipment, or to detect changes in grade within a sector. Because of confidentiality restrictions, it was not possible to match unambiguously capacity costs of pulp and paper or board to get an overall figure for integrated capacity in a particular sector. As was mentioned in Section 7, several of the capital cost estimates, e.g. Glassine and Greaseproof and Cotton Fibre, seem low.

Total annual treatment costs for new capacity are taken as equal to the average treatment costs for the third of mills in each product sector with lowest production costs. This method only uses costs of existing sources rather than new sources, and the latter are significantly higher. However, there are problems in using the new source costs because base capacity expansion costs may include BPT costs as well. (See the discussion of new source costs in Section 7.)

Finally, only the price series used in the demand curve for each sector was used in the present value calculation. If prices of different grades vary significantly, that price series may not be consistent with the specific observations on capital costs from the 308 Survey. However, the estimates of the change in present value due to BCT costs should be stable.

The comparison of cash flow and capital requirements depends on the sector-specific estimates of cash flow, the forecast of capacity expansion in each subcategory, including the mix of existing and new sources, costs of compliance, and the capital costs of new capacity. The cash flow estimates are based on revenues and costs taken from the demand/supply analysis. Revenues are the product of total output and and price. However, in sectors with a variety of different grades, the price used may not have been the sector-wide average price, so revenues may be under- or over-estimated. Unfortunately, other information on cash flow broken down by product sector is not available. Revenue estimates would also be affected by using a different macroeconomic forecast for the base case. However, it is unlikely that these changes would significantly affect the overall financial evaluation of the industry, although the evaluations for individual sectors might change.

The forecast of capacity expansion in each subcategory was based on the present mix of subcategories in each product sector and the belief that most expansion would be in integrated mills. Total costs of compliance also depend on the fraction of new capacity subject to NSPS requirements. As was noted in Table 8-2, assuming that all new capacity after 1982 is subject to NSPS, total capital costs are raised about 6.3 percent. This does not significantly affect the cash flow analysis presented in Section 7.

As mentioned earlier, there is considerable uncertainty about the base costs of new capacity. Since costs of capacity expansion in a single year are larger than total costs of compliance in any of the treatment options, these estimates have an important effect on the overall financial picture of the industry, although they do not affect the estimate of the incremental effect of BCT regulations.

The mill-specific capital availability analysis presented in Table 7-27 assumed that normal reinvestment costs were deducted from cash flow. Table 8-4 presents alternate estimates of the number of mills which have investment costs greater than cash flow under the Proposed Regulation and the Alternative Options when reinvestment is not deducted. For example, this occurs for 44 mills rather than 57 mills under the Proposed Regulation.

## Closure Analysis

A major strength of the mill closure analysis is that it performs a present value analysis of every mill in the 308 Survey. This is a much more reliable way of locating mills with possible hardships than trying to extrapolate the results for the entire industry on the basis of a few model mills. Nevertheless, use of survey data which may be several years old does present problems. Another important limitation is that the closure decision may depend partly on variables not included in the survey. However, as will be shown below, the forecast of closures due to BCT costs is quite stable, although the estimate of base closures does vary with the assumptions and decision rules used.

As was discussed in the section on supply curves, costs reported in the Survey are not adjusted for real increases between 1978 and 1983-85. This suggests that costs are underestimated by 5 to 15 percent. On the revenue side, recall that individual mill revenues are adjusted by a factor (the ratio of revenues in the 308 Survey to revenues calculated using 1978 product sector prices) to account for variations

TABLE 8-4. Comparison of BCT/BAT Investment Costs and Annual Cash Flows of Individual Mills by Major Subcategory Type: Reinvestment Costs not Deducted from Cash Flow

| Total Number of Direct Dischargers = 347 | ---Number of Mills--- | | | |
|---|---|---|---|---|
| | Range of Ratio Investment Cost / Cash Flow | | | |
| | 1-1.5 | 1.5-2 | >2 | Total |
| Proposed Regulation | | | | |
| Integrated | 11 | 5 | 8 | 24 |
| Secondary Fiber | 6 | 2 | 6 | 14 |
| Nonintegrated | 3 | 2 | 1 | 6 |
| Total | 20 | 9 | 15 | 44 |
| Alternative Option 1 | | | | |
| Integrated | 7 | 1 | 5 | 13 |
| Secondary Fiber | 3 | 0 | 3 | 6 |
| Nonintegrated | 2 | 1 | 0 | 3 |
| Total | 12 | 2 | 8 | 22 |
| Alternative Option 2 | | | | |
| Integrated | 15 | 4 | 9 | 28 |
| Secondary Fiber | 5 | 0 | 6 | 11 |
| Nonintegrated | 2 | 2 | 1 | 5 |
| Total | 22 | 6 | 16 | 44 |
| Alternative Option 3 | | | | |
| Integrated | 22 | 6 | 17 | 45 |
| Secondary Fiber | 4 | 3 | 7 | 14 |
| Nonintegrated | 5 | 1 | 2 | 8 |
| Total | 31 | 10 | 26 | 67 |
| Alternative Option 4 | | | | |
| Integrated | 11 | 5 | 11 | 27 |
| Secondary Fiber | 7 | 2 | 8 | 17 |
| Nonintegrated | 3 | 2 | 1 | 6 |
| Total | 21 | 9 | 20 | 50 |

Source: Meta Systems estimates.

in the prices received by each mill which presumably reflect differences in grade. The analysis assumes that this adjustment factor remains constant between 1978 and 1983-85, but there is no way to verify this. A further limitation is that a mill's output in 1983-85 is assumed equal to the level in the Survey. Even if one could extrapolate to other levels of output by assuming constant unit variable costs, it is not evident what level of output should be chosen.

Certain gaps in the coverage of the Survey were detected. Although salvage value, cost of capital, and useful life of the mill are important variables, they had to be inputed from other variables. Inconsistencies in the handling of pulp purchases and production meant that in some cases an overall material balance of pulp purchased, consumed or sold should not be calculated.

For any mill selected as a closure candidate, the direct employment impact estimated should be quite accurate. Mill employment data is obtained from the 308 Survey of the technical contractor in almost all cases. When not available, employment is imputed using average productivity for each subcategory. These averages are based on 308 Survey data.

The reliability of the data is a fundamental problem, and is particularly acute in the closure analysis because so many different variables are used. The problem is increased by confidentiality restrictions which lessen the chance that inconsistencies or implausible responses will be uncovered in individual surveys. In the course of the analysis, a number of anomalous mills were detected, including some which reported very low unit revenues but were not transfer mills (i.e. integrated with converting operations) and reported no intention to close. Also, because of confidentiality, total impacts on individual firms could not be estimated.

The comparison of salvage value and the present value of remaining open can only approximate the closure decision. Other factors such as costs of laying off workers or benefits of integrated operation cannot be taken into account. The analysis can only indicate which mills appear financially weak. However, the large number of mills in the industry which transfer some of their output adds a complicating factor to the analysis. Most transfer mills calculated revenues on some basis other than market revenues and tended to underestimate the market value of their output. Because of this underestimation and because of the advantages of integrated operation, it could be argued that transfer mills should be excluded from the closure analysis. However, they were retained (although treated slightly differently, see below) because of their large numbers and because on average, the fraction of predicted closures for transfer and non-transfer mills did not differ significantly. However, several predicted closures turned out to be transfer mills with very low revenues (unit revenues less than $100/ton), so they were excluded.

Although the effects of many of these variables on the closure analysis could not be determined, the sensitivity of the closure analysis to variations in some key parameters and decision rules was tested. In general, the number of predicted closures due to treatment costs was much more stable than the number of base case closures. This is because a variation in a parameter or decision rule tends to affect the probability of closure in both the base case and treatment option in a similar way. For example, increasing salvage value increases the number of closures due to treatment costs, but it also causes certain mills which were closures due to treatment costs but not base closures to become base closures as well.

Table 8-5 shows the effect on the results of the closure analysis of different values of $\beta$, the fraction of book value of the mill which is considered salvageable (see Section 2). The base case value was .125, and the alternative values are 0 and 0.3. The results are given for the Proposed Regulation, and are similar for other treatment options. Raising $\beta$ from 0 to 0.3 increases the opportunity cost of staying open, and increases the number of base closures by three. However, the number of option closures increases only by one.

In the base analysis, the rule that a mill would not close if it was better off financially in 1983-85 than it reported in the 308 Survey was applied only to transfer mills. Table 8-5 shows the effect of applying this rule either to no mills or to all mills. Applying the rule to all mills rather than no mills reduces base closures by 54 mills but option closures by only one mill.

Particularly dramatic results occur when the revenue estimates for both the 1983-85 base case and the Proposed Regulation are varied by plus or minus ten percent. The results are also given in Table 8-5. The estimate of base closures is 178 mills higher using the low rather than the high revenue estimate, but the number of added closures due to treatment costs increases by only six.

Mills with greater than 20 percent of their production in the All Other Paper or Molded Pulp sectors were excluded from the closure analysis because no data were available to do a demand/supply analysis. However, a separate analysis was done for them using base prices of $565 per ton for All Other Paper and $608 per ton for Molded Pulp. Of the twenty-eight mills analyzed separately, three were predicted base case closures even in the absence of BPT costs for Molded Pulp.

TABLE 8-5. Sensitivity Analysis of Closure Results: Proposed Regulation

| | Changes in Number of Mills from Base Forecast | | |
|---|---|---|---|
| | | Added Impacts of Proposed Regulation | |
| Variant | Base Case Closures | Closures | Reopenings |
| 1. β = 0 | - 2 | 0 | +1 |
| 2. β = 0.3 | + 1 | +1 | 0 |
| 3. "Better than 1978" rule applied to no mills | + 38 | -1 | +1 |
| 4. "Better than 1978" rule applied to all mills | - 16 | -2 | -2 |
| 5. 1983-85 revenues ten percent higher | - 44 | -6 | -4 |
| 6. 1983-85 revenues ten percent lower | +135 | 0 | +4 |
| Totals for Base Forecast* | 56 | 7 | 4 |

*From Table 7-28.
Source: Meta Systems estimates.

Adding BPT costs for the Wastepaper Molded Products subcategory and BCT costs for all direct dischargers did not produce any added closure candidates, even when no price increase was forecast.

The number of base closures, 57, is somewhat large. It was theorized that the base closures had unusually large BPT costs. However, a comparison of $/ton BPT costs of base closures with average $/ton BPT for all mills in the 308 Survey did not confirm this. Therefore these closures probably result from the reasons given in Section 7, i.e. a number of smaller, nonintegrated mills are vulnerable because of significant new capacity in several sectors, and high variable costs including energy and pulp.

## Indirect Earnings and Employment Effects

The estimates of indirect earnings and employment impacts rest on a very simple input/output framework. On one hand, the approach tends to overestimate impacts because it does not take into account that many workers who lose their jobs because of closures will find new jobs elsewhere. On the other hand, impacts are underestimated because they do not include mills which reduce output somewhat but do not shut down. However, an alternative method calculating employment losses based on output losses and average productivity gave roughly similar results. In fact, in some cases the employment effects obtained this way were less than those from the closure analysis.

## Balance of Trade Effects

The analysis of the effect of BCT regulations on the international trade position of the pulp and paper industry is only qualitative because of data and model limitations. A rigorous analysis would require information about demand and supply elasticities in the relevant foreign markets and the net effects of projected pollution requirements and subsidies on the production costs of foreign competitors.

In lieu of such an effort, the main task is to identify product sectors which have a large current or potential share of exports or imports in total production and which face significant cost increases under BCT regulations. The only sectors which meet those criteria are Newsprint, Dissolving Pulp (Alkaline mills) and possibly Bleached Linerboard. The price impacts and/or trade involvement of other sectors are sufficiently small that a more detailed analysis of them is not necessary.

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